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# BIOLOGICAL EVALUATION OF WESTERN SPRUCE BUDWORM ON 1992 ANALYSIS UNITS ON THE UMATILLA AND WALLOWA-WHITMAN NATIONAL FORESTS


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## Introduction

Resource values associated with forests in the Blue Mountains are becoming degraded from a number of causes: a variety of insect and disease problems are causing growth loss, defect, and mortality to growing stock; threat of damage from wildfire is increasing due to high fuel loads and increased fuel ladders; and watershed damage has resulted from inappropriate harvesting activities, or the inappropriate timing of those activities in some drainages. These and other factors have impacted forest health and affect our ability to achieve Desired Future Condition for the various resources as described in our Forest Plans.

Continued high and increasing populations of western spruce budworm, *Choristoneura occidentalis* Freeman, in the Blue Mountains of northeastern Oregon and southeastern Washington, have caused concern for timber, wildlife, fisheries, visual quality, recreation, and other resources associated with budworm damaged stands. Public and private land ownerships, alike, are experiencing moderate to severe levels of budworm-caused defoliation and damage in many locations. In addition, five years of drought have weakened trees making them increasingly susceptible to attack by bark beetles.

The Umatilla and Wallowa-Whitman National Forests have identified high-risk stands with potentially adverse effects to resources by the budworm outbreak. This action was prompted by the current and cumulative damage to resources, the increasing budworm populations, and the high level of concern for forest health by federal, state, and local officials, as well as the public. Districts delineated these geographic areas into Analysis Units (AUs) for examination in an entomological evaluation to determine current conditions, past damage, and potential for future damage from budworm. The purpose of this report is twofold: (1) to summarize and document information collected during the field sampling stages of the entomological evaluation; and (2) to describe the probable consequences of either suppressing or not suppressing budworm populations on the Analysis Units in 1992.

Budworm outbreaks can be minimized through long-term solutions such as cultural manipulation of budworm-susceptible stands. Several recent documents pointed this out: <u>Blue Mountains Forest Health Report "New Perspectives in Forest Health"</u> (Gast et al. 1991); <u>Final Environmental Impact Statement "Management of Western Spruce Budworm in Oregon and Washington"</u> (USDA - Forest Service 1989); and various other publications. Since cultural practices will take many years to carry out over large areas, the Forest Service is analyzing the present budworm situation for the need to provide immediate, short-term relief from additional budworm-caused resource damage. Management of western spruce budworm on federal lands uses an integrated pest management approach that may include the use of insecticides.

During the fall of 1990, officials of the Umatilla and Wallowa-Whitman National Forests identi-

fied the need to evaluate budworm populations and damage to stands on several areas on their Forests. Both budworm and Douglas-fir tussock moth (*Orgyia pseudotugata*) were sampled on these areas, as well as on monitoring locations on the Malheur National Forest, during July of 1991 (Scott 1991b). This sampling revealed that budworm larval populations on certain of the Analysis Units were less than the Regional standard of 8 larvae per 3-branch sample (Hostetler 1990), and were dropped from further consideration. Cumulative damage from budworm was so heavy over some Analysis Units that trees would no longer benefit from insecticidal treatment. These Analysis Units were also dropped from further consideration. The Malheur National Forest, in the fall of 1990, indicated no desire to participate in the potential treatment of Analysis Units in 1992; therefore, no additional analysis was conducted on that Forest beyond larval monitoring for budworm and tussock moth this summer.

The Umatilla National Forest has identified three Analysis Units that required further evaluation for potential budworm suppression on the Walla Walla Ranger District: Mill Modified AU, Thimbleberry AU, and Meacham Trail AU. The Meacham Trail AU is the result of merging the original Meacham AU on the Walla Walla RD with the proposed Oregon Trail AU on the La Grande Ranger District, Wallowa-Whitman National Forest. Hence, this Analysis Unit contains forest lands administered by both the Umatilla National Forest and Wallowa-Whitman National Forest, as well as containing private forest lands and some lands administered by the Umatilla Indian Agency.

The Wallowa-Whitman National Forest has identified 4 AUs requiring additional evaluation: Mt. Emily AU and Indian Creek AU on the La Grande Ranger District; and Kuhn-Chesnimnus AU and Morgan AU on the Wallowa Valley Ranger District. The Indian Creek AU is the result of merging the original Indian Creek AU with the proposed Mt. Fanny/Moss Springs AU.

Appendix A contains maps of the seven Analysis Units.

## Background and Historical Information

Western spruce budworm is indigenous to western North America. Low levels of populations are normally found in most stands containing host tree species. This budworm species produces one generation per year. Budworms feed on a wide range of confers during the larval stage when populations reach outbreak. Normally, only six native tree species are considered by most authorities to be principal hosts; they include Douglas-fir, grand fir, white fir, subalpine fir, Engelmann spruce, and western larch.

In the Blue Mountains, these host tree species show varying degrees of vulnerability to damage by budworm. Grand fir, white fir, and Douglas-fir are the host tree species more heavily defoliated by budworm, while subalpine fir and Engelmann spruce normally show low to moderate defoliation by budworm. Western larch appears to tolerate feeding by budworm better than any other host species in the Blue Mountains. Budworm defoliation usually causes only slight damage to larch, even when larch occurs in predominately grand or white fir and Douglas-fir dominated stands with high budworm populations. The important damage to western larch from budworm is to the developing cones and subsequent decline in seed production, which seriously affects the ability to regenerate forest sites naturally, as well as to collect seed for use in artificial

regenerations of western larch (Fellin and Dewey 1986). Budworm populations frequently impact Douglas-fir seed crops in a similar manner.

For this analysis, I considered the principal budworm host tree species to include grand fir, Douglas-fir, subalpine fir, and Engelmann spruce. These species occur in mixed conifer stands throughout all of the proposed 1992 Analysis Units.

Defoliation to trees occurs only during the larval stages of budworms–the stages during which budworm feed. Young larvae (second instars) that overwintered become active in the spring when temperatures persist for several days above 42°F. This also coincides with host tree phenology and the development of buds (Beckwith and Kemp 1984; Wagg 1958). Initially, small larvae mine in previous year's needles and developing buds, often destroying buds before they open. Later, after budburst, larvae feed on foliage of expanding shoots, often webbing needles together to form a feeding shelter. By early to mid-summer, damaged needles, and needle fragments caught up in webbing, dry and turn red, and give branch tips of trees a scorched-like appearance. Stands in which heavy defoliation has occurred for several consecutive years will often result in thin crowns, bare tops or dead tops. Suppressed sapling and pole-size trees in the understory may also be killed. Trees weakened by budworm, drought, and possibly other factors begin to be attacked by bark beetles of the family Scolytidae if budworm populations persist in these stands. At the end of budworm outbreaks, trees that have survived the defoliation and have adequate carbohydrate (starch) reserves, will usually refoliate and recover within a few years. Often, these trees will have sustained measurable amounts of radial and height growth loss, top-kill, and tree defect (Van Sickle 1985, 1987).

A number of processes acting independently, or in concert, occur in trees during periods of drought, increasing the susceptibility of trees to insects, and increasing the survival and growth of insects as well as pathogens (Mattson and Haack 1987). The forests of northeastern Oregon and southeastern Washington have experienced five years of drought. The prolonged period of warm weather, increased insolation and soil temperatures, and subnormal moisture conditions have not only been favorable to budworm populations, but have added further stress to trees already weakened by defoliation and have promoted the buildup of populations of bark beetles in several locations.

Stands with low-vigor host trees brought about by injuries from defoliation and other factors, overstocking, old age, infection with disease-causing organisms, drought, etc., are attractive to bark beetles. These influences cause severely stressed trees to undergo many changes in biochemical and physiological processes. Changes in plant biochemical composition during drought, for example, are well documented (see Mattson and Haack 1987). Drought-induced changes in the composition and concentration of terpene emissions from conifers influence the behavior of bark beetles. Bark beetles use these host odors to locate and successfully attack and kill living, but stressed, conifers with reduced defenses.

Budworm populations periodically increase to outbreak when conditions are favorable. The enormous increase in budworm habitat since the late 1800's and early 1900's have encouraged development of defoliator outbreaks throughout the West (Anderson et al. 1987; Gast et al. 1991; Swetnam and Lynch 1989). True fir and Douglas-fir components in stands that were predominately pine-dominated in the past, and that were maintained in that condition by naturally-occurring ground fires, now dominate vast areas of the Blue Mountains. The ability of these shade-tolerant species to germinate and grow in the shade of overstory trees has led to over-

stocked stands with multi-storied canopies of principal budworm hosts. These conditions are ideal habitats for budworm. Populations of budworm can develop to outbreak levels, especially during periods of drought which favor survival and rapid development of the larvae.

The pattern of defoliation in the Blue Mountains over the past decade (fig. 1) shows that the current budworm outbreak began in 1980. The outbreak peaked in 1986 and began to decline through 1989. Budworm populations increased again during 1990 and continued to increase in 1991 based on preliminary aerial survey sketch mapping (aerial survey data for 1991 was not available in time to prepare this report). Populations are now causing more damage, and trees that began to recover are now being defoliated again. In addition, some new areas of defoliation are showing up as budworm populations expand and disperse from adjacent high infestation areas.

Budworm defoliation on the Walla Walla Ranger District was first detected in 1984, based upon aerial insect detection survey data (fig. 2). Defoliated acres increased each year until reaching a peak number of acres defoliated in 1987. The defoliation trend in the years after 1987 are similar to the budworm defoliation trend seen throughout the Blue Mountains (fig. 1).

Defoliation by western spruce budworm began earlier on the La Grande Ranger District (fig. 3). Budworm defoliation on the La Grande District began in 1980 within the Indian Creek Analysis Unit. Acres with defoliation rapidly increased throughout this area and other areas of the La Grande Ranger District, and throughout the Blue Mountains, in following years. Defoliated acres peaked in 1987 followed by a large decrease in defoliated areas in 1988 and 1989.

A mild winter during 1989-1990, and continued warm, dry weather during the summers, favored the budworm. Populations increased in both 1990 and 1991 to levels similar to those of 4 or 5 years earlier (fig. 3). The La Grande Ranger District, and specifically the Indian Creek Analysis Unit, now have experienced the longest period of defoliation occurring anywhere in the Blue Mountains (table 1). Parts of the Indian Creek AU have had 12 consecutive years of budworm defoliation.

The budworm outbreak developed later on the Wallowa Valley Ranger District (fig. 4). Although a very small area of defoliation was mapped within the boundaries of the Morgan Analysis Unit as early as 1980 (ref. aerial insect detection survey Map for 1980 on file at USDA Forest, Pacific Northwest Region, Forest Pest Management, Portland, OR), no other defoliation was mapped on the district until 1986 (fig. 4). The current outbreak increased in size on the district, reaching a peak in 1988. The outbreak declined considerably in 1989, but began increasing again the following season.

The 1988 Meacham Pilot Project to evaluate different formulations of the biological insecticide, *Bacillus thuringiensis* (*B.T.*), treated portions of the proposed Meacham Trail Analysis Unit on the Walla Walla and La Grande Ranger Districts. The Pilot Project required other large areas within the Project boundaries to remain untreated as check areas for the Project. These large untreated areas, as well as infested stands outside the Analysis Unit boundary, greatly contributed to the reinvasion of treated areas within just a few years after treating.

## Recent Defoliation Trends

Recent trends in budworm defoliation on the proposed 1992 Analysis Units were determined from

aerial insect detection survey data from the 1989, 1990, and 1991 flights. Defoliation severity level and the proportion of acres in each class were computed for plotting by Analysis Unit from digitized survey data.

Three defoliation classes are used in this report, with regard to aerial survey data. Light defoliations are areas with trees whose crowns appear with reddish cast to the branch tips, in which the current year's foliage has been defoliated or damaged by that year's populations of budworm. Moderate defoliations are areas with trees who's crowns showed defoliation from the current year's budworm populations and in addition, defoliation from previous years have resulted in some bare tops, with some gray color evident in the tops, and green foliage still present on tree crowns. Heavy defoliations are areas with trees who's crowns contain defoliation from the current year's feeding by budworm, have bare tops visible, varying in degree from moderate to very gray as evident from the air, and with some, to no green foliage visible in host tree crowns.

Based upon the last three year's defoliation mapping on the Meacham Trail and Thimbleberry Analysis Units on the Walla Walla Ranger District, there is a gradual shift in the severity of defoliated acres mapped from the light level of defoliation to the moderate and heavy defoliation levels, as cumulative damage to host trees occurred (fig. 5). By contrast, the proportion of defoliated areas on the Mill Modified Analysis Unit has not changed during the last three years. Light defoliation has been consistently mapped in this Analysis Unit for at least the last three years in the aerial insect detection survey (fig. 5).

The defoliation the last three years on the La Grande Ranger District Analysis Units shows a shift in defoliation intensity similar to the Walla Walla Ranger District Analysis Units. Fewer acres of the area were mapped as light, and more acres were mapped as medium or heavy recently (fig. 6). Most acres on both Analysis Units were mapped with moderate defoliation during 1991.

The Wallowa Valley Ranger District's Analysis Unit acres declined in the proportion of lightly defoliated acres, and increased mostly in the proportion of moderately defoliated acres (fig. 7). Both the Morgan and Kuhn-Chesnimnus Analysis Units in 1991 had only very slight increase in the proportions of heavily defoliated area.

## Methods

### Analysis Unit Characteristics and Management Concerns

All the proposed 1992 Analysis Units contain a very high proportion of the total trees per acre in budworm host species (ranges between 72-94% host trees/acre). Douglas-fir/grand fir, or Douglas-fir/true fir mixed conifer stands occur throughout the Analysis Units. These community compositions are generally based upon the large proportions of Douglas-fir and grand fir trees per acre and basal area per acre stocking, and the fact that all Analysis Units contain the majority of understories regenerating to Douglas-fir and grand fir.

Plant communities and species compositions vary considerably within each Analysis Unit. Moreover, each Analysis Unit has unique distributions of varying management strategies and resource values that are at risk from the impacts of budworm. The following paragraphs briefly consider the characteristics, issues, and concerns on each of the Analysis units.

**Meacham Trail Analysis Unit:**

Most of the Meacham Trail Analysis Unit falls roughly in T.1N., R.35 & 36E.; T.1S., R.35 & 36E.; and T.2S., R.36E. (see Appendix A). The Analysis Unit covers 41,662 acres. The U.S. Forest Service (Walla Walla and La Grande Ranger Districts) administers about half of this area. Private ownerships make up the remaining half, and includes parcels of lands belonging to Boise Cascade, Louisiana Pacific, Cunningham Sheep, and other non-industrial private owners.

Budworm has been present in some stands within the Meacham Trail Analysis Unit for at least seven years (table 1) based on aerial insect detection survey maps showing visible budworm defoliation.

Grand fir and Douglas-fir, with smaller amounts of subalpine fir and Engelmann spruce comprise the major host species in stands of this Analysis Unit (table 2). Ponderosa pine makes up most of the remaining species on the Analysis Unit (i.e., trees/acre). Lodgepole pine and western larch also occur in places within the Analysis Unit.

[Note: Budworm-caused damage to stands was evaluated in stand examinations conducted by district crews. These data, in part, form the basis for this report. Budworm host-type comprised the majority of stands that were sampled; thus, the stand data collected may not reflect actual proportions of trees per acre by all species that occur over the entire Analysis Unit. Instead, data more likely reflects the species composition and stocking levels of mostly budworm susceptible stands on the Analysis Unit.]

The Meacham Analysis Unit includes areas designated in Forest Plans as Viewshed, Dedicated Old growth, Wildlife Habitat, Riparian (fish and wildlife), and Grass-Tree Mosaic. A portion of the Analysis Unit acres are included in the Scheduled Harvest for the Umatilla and Regulated Harvest for the Wallowa-Whitman National Forests. The Meacham Trail Analysis Unit is scheduled for an Integrated Resource Analysis on a portion of the area.

The budworm outbreak presents a risk to several resource values and issues on this Analysis Unit. Areas within the Viewshed, Wildlife Habitat (big game cover), and Riparian strategies are within the Forest Plan Scheduled Harvest and represent a portion of the timber volume at risk on this Analysis Unit. Meacham Creek contains anadromous fish habitat; and stream shading is at some level of risk of reduction from budworm defoliation along this creek and its tributaries. Wildlife habitat for elk is also at risk of degradation through loss of cover for thermoregulation, hiding, and escapement.

**Thimbleberry Analysis Unit:**

The Thimbleberry Analysis Unit falls approximately within T.2N., R.36 & 37E.; T.1N., R.36 &37E.; and T.1S., R.36 & 37E. (see Appendix A). The Analysis Unit covers 66,474 acres. All but about 3,800 acres are U.S. Forest Service administered lands. The private lands are mainly Boise Cascade, but some non-industrial private lands also occur in this Analysis Unit.

Budworm has been present in stands within the Thimbleberry Analysis Unit for at least six years (table 1).

Grand fir and Douglas-fir make up a large proportion of the tree per acre stocking on the Anal-

ysis Unit according to stand data from stand examination plots. Subalpine fir and Engelmann spruce make up a small proportion of the trees per acre stocking of budworm host species (table 2). Ponderosa pine and western larch also occur in small proportions within host stands on the Analysis Unit.

The Thimbleberry Analysis Unit includes areas designated in the Umatilla Forest Plan as Viewshed 2, Roaded Natural, Special Interest Areas, Dedicated Old Growth, Wildlife Habitat, Riparian (fish and wildlife), and Grass-Tree Mosaic. Management strategies in the Thimbleberry Analysis Unit that are part of the Forest Plan Scheduled Harvest of timber include management strategies for Viewshed, Roaded Natural area, Wildlife Habitat, and Riparian. These acres make up approximately 52% of the Analysis Unit acres. Portions of the Thimbleberry Analysis Unit are now under an active timber sale.

The volume of timber that is at risk under scheduled harvest, and the effects of budworm on anadromous fish habitat, are primary concerns on this Analysis Unit.

### Mill Modified Analysis Unit:

The Mill Modified Analysis Unit is located in T.8N., R.40E.; and T.7N., R.39 & 40E. (see Appendix A). The Walla Walla Ranger District administers nearly all of the 9,566 acres in this Analysis Unit. Only two acres of private land occurs within this Analysis Unit.

Budworm defoliation has been detected in this Analysis Unit the shortest time of any of the Analysis Units. Aerial insect detection surveys have mapped defoliation on the Mill Modified AU since 1988 (Table 1).

Grand fir is the most frequent occurring budworm host species on the Analysis Unit, followed by subalpine fir and Douglas-fir (Table 2). Ponderosa pine, western larch, lodgepole pine, and Engelmann spruce are minor species.

The Analysis Unit contains acreage that falls under several different management strategies of the Umatilla National Forest Land and Resource Management Plan. These include Off-highway motorized semi-primitive recreation, visual resources (Viewshed 1 and 2), Developed Recreations, Dedicated Old Growth, Riparian (Fish and Wildlife), and Timber and Big Game.

Forest Plan Scheduled Harvest includes about 78 percent of the Analysis Unit acres. These include management strategies for Viewsheds, Timber and Big Game, and Riparian. This large proportion of the Analysis Unit acres contains harvestable timber volumes at risk of damage or loss from budworm, and represents one of the issues identified by the district for this Analysis Unit. Anadromous fish habitat of the Touchet River and Ski Bluewood, a developed ski resort and winter recreation facility, which is continuing to be developed and improved by the concessionaire/proprietor, are other values and issues identified for this Analysis Unit.

### Mt. Emily Analysis Unit:

The Mt. Emily Analysis Unit is located in T.1S, R.37 & 38E.; and T.2S, R.36, 37 & 38E. (see Appendix A). The Analysis Unit contains 32,327 acres. The La Grande Ranger District administers most of acres. The Walla Walla Ranger District administers a smaller portion (1,045 acres). The Analysis Unit also contains 655 acres of non-industrial private lands.

The aerial insect detection survey has detected budworm defoliation on this Analysis Unit since 1985. The outbreak is now in its seventh year (Table 1).

Budworm host species predominate with over half the trees per acre in grand fir, and over a quarter of the trees per acre in Douglas-fir (Table 2). Subalpine fir and Engelmann spruce occur in minor proportions on the Analysis Unit (Table 2). Ponderosa pine, lodgepole pine, and western larch make up the remaining species within stands.

The Mt. Emily Analysis Unit contains acreage covering 3 management strategies of the Wallowa-Whitman National Forest Land and Resource Management Plan, and 2 management strategies of the Umatilla National Forest Plan. Most of the area (24,414 acres) is Wildlife, Summer Range emphasis under the Wallowa-Whitman Plan, but in addition, contains Timber Emphasis and Old-Growth Forest strategies. The Umatilla National Forest administered lands within this Analysis Unit include Viewshed strategies and Wildlife Habitat strategies.

There are several resource values and management issues of concern on this Analysis Unit considering the current budworm outbreak. Several of the Forest Plan management strategies for this Analysis Unit include Scheduled or Regulated harvest of timber. Much of the Mt. Emily Analysis Unit includes either active or proposed silvicultural projects that have long-term reduction of forest and stand susceptibility to the budworm objectives. Most activities will occur within the next five years. Wildlife Habitat for big game, and Recreation and Visual Quality objectives–especially along FS road 31, and Mt. Emily proper–are at risk from budworm, as well.

**Indian Creek Analysis Unit:**

The Indian Creek Analysis Unit is across the Grande Ronde Valley from the Mt. Emily Analysis Unit, on the eastside of the valley, in T.1S., R.41E.; T.2S., R.40 & 41E.; and T.3S., R.40 & 41 E. (see Appendix A). The Analysis Unit contains 28,885 acres, with 25,327 acres administered by the La Grande Ranger District, 2,440 acres owned by Boise Cascade, and 1,118 acres of non-industrial private ownership.

The aerial insect detection survey mapped budworm defoliation on portions of the Analysis Unit since 1980, the year the current outbreak began. The outbreak is now in the 12th year on portions of the Indian Creek Analysis Unit (Table 1). Budworm has defoliated certain areas of the AU a much shorter period of time. Thus, damage from budworm is not uniform over the entire Analysis Unit.

Budworm is damaging principally grand fir hosts on this Analysis Unit. Nearly 50 percent of the trees per acre are grand fir. More or less equal proportions of Douglas-fir, subalpine fir, and Engelmann spruce make up other principal budworm host species on the Analysis Unit (Table 2). Ponderosa pine, lodgepole pine, and western larch also occur as minor stand components of budworm susceptible stands. It is noteworthy that sizeable stands of nearly pure western larch and lodgepole pine occur within the Analysis Unit. The larch stands, though surrounded by light or moderately budworm defoliated mixed conifer stands, are relatively unbothered by budworm.

Forest Plan resource management allocations occurring within the Indian Creek Analysis Unit include Timber Emphasis, Wildlife, Roadless Recreation/Backcountry, Research Natural Area, and Old-Growth Forest. About 68 percent of the Wallowa-Whitman administered lands are within Timber Emphasis allocations, and 22 percent are Wildlife allocations that also permit vegetation

manipulation. The remaining Wallowa-Whitman acres are divided among the other resource allocations.

Issues and concerns for this Analysis Unit include the impact of budworm-caused damage to several resource values. The Regulated Harvest for the Wallowa-Whitman Forest Plan includes large portions of this Analysis Unit's acres. Portions of this area are at risk from budworm. Much of the Indian Creek Analysis Unit includes either active or proposed silvicultural projects. These have long-term objectives of reducing budworm habitat and sustaining vigorous forest growth by increasing the composition of ponderosa pine, western larch, and lodgepole pine in the stands, and thinning to regulate stand density and improve tree vigor. Plans are to conduct activities to achieve these objectives within the next five years on this Analysis Unit.

Other non-timber resource concerns have also prompted the consideration of this Analysis Unit for suppression of budworm. Indian Creek represents anadromous fish habitat for several species of fish affected by increases in water temperatures resulting from loss of shading by budworm defoliation. Several thousand acres of mixed conifer stands represent big game habitat which is at risk of damage by budworm. Also, Recreation and Visual Quality Objectives are compromised due to budworm-caused damage to scenic areas along FS road 62, and Moss Springs Campground which serves as a high-use recreation area for many users of the Eagle Caps Wilderness, and surrounding non-wilderness forests.

**Kuhn-Chesnimnus Analysis Unit:**

The Kuhn-Chesnimnus Analysis Unit is located on the Wallowa Valley Ranger District in T.3N., R.43, 44 & 45E.; and T.2N., R.44 & 45E. (see Appendix A). The Analysis Unit contains 63,300 acres. The Wallowa Valley Ranger District administers most of these acres. Smaller industrial private acres, including holdings by Boise Cascade and R-Y Timber, also occurs. A few thousand acres in the Kuhn-Chesnimnus Analysis Unit are also in non-industrial private ownership.

Aerial insect detection surveys detected budworm defoliation on portions of the Analysis Unit since 1986. The budworm populations are now in the sixth year of outbreak on the Kuhn-Chesnimnus Analysis Unit (Table 1).

The Analysis Unit contains roughly 48,200 acres of budworm host-type. Douglas-fir is the most prominent budworm host in mixed conifer stands on the Kuhn-Chesnimnus Analysis Unit, with slightly over 46 percent of the trees per acre on stand exam plots. Grand firs make up a little over 29 percent of the trees per acre. Subalpine fir and Engelmann spruce occur in smaller proportions within budworm susceptible stands (Table 2). Ponderosa pine, lodgepole pine, and western larch also occur in mixed conifer stands, in small percentages, on the Kuhn-Chesnimnus Analysis Unit.

Wallowa-Whitman National Forest Land and Resource Management Plan allocations which occur in areas of the Kuhn-Chesnimnus Analysis Unit include Timber Production emphasis, Wildlife/Timber emphasis, and Old-Growth emphasis.

Budworm defoliation has placed several resources at risk. These include Regulated Harvest acres for the Forest (much of the Kuhn-Chesnimnus Analysis Unit is in active or proposed silvicultural projects which address long-term objectives to reduce susceptibility to western spruce budworm). Other resource concerns or issues are Big Game Winter Range cover, Water Quality and Anadro-

mous Fisheries (the area contains tributaries to both Joseph Creek drainage watershed and the Grande Ronde drainage), Old Growth (stands are increasing in susceptibility to bark beetles due to overstocking, budworm defoliation, and drought), Visual Quality objectives along Highway 3 which run through a portion of the Analysis Unit, and protection of values associated with Swamp Creek, a proposed Wild and Scenic Study River. The budworm outbreak could seriously disrupt much of the district's proposed timber sales and thinning projects in 1992 through 1996. A large volume of the timber sales are within commercial thinning prescriptions for Douglas-fir. These would have to be delayed until after the outbreak because we do not normally recommend thinning during budworm outbreaks (Gast et al. 1991).

**Morgan Analysis Unit:**

The Morgan Analysis Unit is located on the Wallowa Valley Ranger District in T.3S., R.46, 47 & 48E.; and T.4S., R.46, 47 & 48E. (see Appendix A). The Analysis Unit contains 36,400 acres. The Wallowa Valley Ranger District administers nearly all of the area within this Analysis Unit. Five non-industrial private landowners have an additional 568 acres within the Analysis Unit.

The aerial insect detection survey has mapped budworm defoliation on portions of this Analysis Unit since 1986 (Table 1). The outbreak is in the sixth year.

Budworm host species occur in stands on roughly 24,500 acres of the Analysis Unit. A large part of the acres are stocked with grand firs (65.1% of the trees per acre) (Table 2). Douglas-fir makes up a smaller part of host trees in stands (13.8% of the trees per acre). Subalpine fir, Engelmann spruce, ponderosa pine, lodgepole pine, and western large occur as minor species in budworm susceptible stands.

Forest Plan resource management allocations occurring within the Morgan Analysis Unit include Timber Production emphasis, Wildlife/Timber emphasis, and Old-Growth management areas.

The Morgan Analysis Unit contains several resource concerns and issues. The potential damage and losses to timbered acres scheduled for harvest is a major concern (much of the area is under active or proposed commercial timber sales contract or pre-commercial thinning projects within the next five years, with the objective of reducing forest and stand susceptibility to budworm to avoid or lessen budworm problems in the future). Big game wildlife cover in winter range, and especially summer range, are also great concerns in this Analysis Unit (the Canal Fire, which occurred adjacent to this Analysis Unit in 1989, burned through a large portion of big game summer range, reducing the effective cover of the area). Water quality and anadromous fish habitat are of concern from reduced stream shading by budworm defoliation (the area contains portions of the Big Sheep Creek and Upper Imnaha drainages. The spruce beetle, *Dendroctonus rufipennis*, outbreak has severely impacted most of the riparian areas containing Engelmann spruce, and now the residual stands are threatened by budworm defoliation). Damage or losses in old-growth stands are major issues (both bark beetles and budworm, as well as drought, are impacting these stands).

<u>Sampling Design and Procedures</u>

Crews from each Ranger District sampled Analysis Units according to Regional standards and guidelines for sampling western spruce budworm populations on proposed Analysis Units (Hostetler

1990). The sampling procedure used a tiered approach in which the results of the current phase (or tier) of sampling determined the need for additional sampling.

Essentially, we used two sampling tiers to obtain three different types of sampling data. Tier 1 involved lower crown sampling of budworm larvae using the Lower Crown Beating Procedure (LCB) (Mason et al. 1989; Scott 1991a; Scott 1991c). Meeting or exceeding the density threshold average on Analysis Units of 8 larvae per 3-branch lower crown sample, with 90 percent confidence, would prompt the second tier of sampling. Tier 2 sampling involved deployment of pheromone traps to predict defoliation intensities the following year based upon moth captures the current year; and secondly, the collection of tree damage data from stand examination plots within the Analysis Unit.

Larval Sampling:

The design of larval sampling by LCB made use of multiple-stage sampling statistics in the form of a two-stage design. The sampling design employed plots as the first sampling stage, and trees within plots as the second sampling stage. Sampling intensity varied by Analysis Unit, and by sampling tier. Crews conducted Lower Crown sampling on the Analysis Units at 7 to 64 locations. All Analysis Units were sampled at a minimum of 40 locations except for Mt. Emily AU, which had 7. The lower number of locations sampled on the Mt. Emily AU resulted from redrawing the Analysis Unit boundary to facilitate merging the Meacham and Oregon Trail Analysis Units, sometime after the completion of lower crown sampling. This action resulted in shifting some of the Mt. Emily AU lower crown sampling points to the Meacham Trail AU. By the time districts took this action, it was too late to obtain additional larval samples on the Mt. Emily AU.

Sampling crews selected sampling locations as randomly as possible over the Analysis Units as the existing Forest road systems would allow. Crews attempted to distribute the locations to represent the variety of stand conditions about host species composition, site, stocking, age, aspect, elevational differences, and other factors present over the Analysis Units. Crews sampled locations several hundred feet off the road to avoid road dust.

Crews sampled stands containing Douglas-fir and grand fir (and occasionally subalpine fir and Engelmann spruce) at each location (plot) by haphazardly selecting trees during a "walk-through" of the plot area. Sample trees contained new flush of foliage in the lower crown branches, and could be reached from the ground with the sampling equipment. Crews sampled a total of 10 trees on each plot by LCB. Trees varied in size, but crews attempted to sample host trees mostly 20 feet tall or taller, and limit sampling to the lower crown-third. A "sample" from each tree consisted of three lower crown branches from around the crown perimeter. Crews sampled only the apical 45 cm (approx. 18 in) of each branch (Scott 1991c). The procedure was repeated for each sampling location of each Analysis Unit.

The sampling design was a slight change of that used for midcrown sampling of budworm populations in which densities could be estimated over an Analysis Unit at a level of precision of 20 percent (sampling Error = $\pm$ 0.20) and with a 90-percent chance that the true mean would fall within the sampling error. We analyzed budworm population data obtained from lower crown sampling on Analysis Units with a computer program (MUST) for Multi-Stage Sampling (Hazard and Stewart 1974).

Pheromone Trapping:

Adult male budworm were captured in sticky coated "milk carton" style, deltoid shaped traps, baited with a lure containing the synthetic mimic of the western spruce budworm adult female (moth) pheromone or sex attractant. We counted the number of moths captured in traps to obtain the data for the second tier of budworm sampling on Analysis Units.

Crews placed traps on host trees at each pheromone trap site. The lure used was a 92:8 blend of (E)-11 and (Z)-11 tetradecenal. All baits were about 3- by 5-mm polyvinyl chloride pellets impregnated with the pheromone at a strength of 0.0001 percent pheromone by bait weight. One pellet was placed on a pin and attached to the inside of the sticky trap. Baits were placed so not to touch the sticky substance coating the inside walls of the trap.

This sampling technique was designed to obtain adult budworm moth population data to predict budworm defoliation intensities the following season. The procedure uses a regression relationship between moth captures and subsequent season's defoliation (personal communication with Charles Sartwell, USDA Forest Service, PNW Research Station, retired).

The scheme we followed, based on Sartwell's preliminary research to predict defoliation levels from pheromone trap captures is as follows:

| Moths/Trap | Defoliation Description | Defoliation Intensity |
|---|---|---|
| 0-4 | Defoliation undetectable by cursory observation | Light |
| 5-19 | Patchy defoliation within some trees | Light |
| 20-34 | Most trees lightly defoliated | Light |
| 35-44 | Stand moderately defoliated | Moderate |
| 45-55 | Heavy defoliation of upper crowns | Heavy |
| >55 | Heavy defoliation of entire crowns | Heavy |

The description and intensity of defoliation relates to what one would view from the ground. Defoliation would probably appear less severe when viewed from the air.

Crews sampled between 30 and 41 locations on each Analysis Unit during late July and early September 1991 using the budworm pheromone traps. Crews placed one trap at each location on the Analysis Units at about the time budworm pupation began on each Analysis Unit. The locations were within the proximity of the locations sampled by LCB.

Traps were hung at about head height near branch tips, so that both ends of the trap were open and unblocked by foliage. Crews recorded the location of each trap on a Trap Location data sheet, and also marked the location on a district transportation map, so as to facilitate relocation for trap retrieval.

Pheromone traps remained in the field from 4 to 6 weeks. After this time, district crews examined the traps in the field, counted and recorded the number of budworm moths captured in each trap, and returned the traps to the district office for verification by an Entomologist or disposal.

Tree Damage Stand Examinations:

Stand examinations to determine present year and cumulative damage to host trees by budworm is the second part of Tier 2 budworm sampling on Analysis Units.

District crews conducted stand examinations on each Analysis Unit during the time between pheromone trap placement and collection. Crews obtained tree damage data on plots at the same locations where they deployed pheromone traps earlier. In addition, they took extra stand exam plots on several of the Analysis Units, to represent stands that were indicative of different damage conditions, not represented on other stand exam plots.

Crews conducted stand examinations according to the Region 6 Stand Examination Program (UDSA Forest Service 1991). Crews used Standard Exam type protocol with slight modification (see Hostetler 1990).

At each of the pheromone trap sites, crews established a 20 BAF variable radius plot (for trees > 2.9 in. DBH) and a 1/300-acre fixed radius plot (for trees < 3 in. DBH). We recorded all stand exam plot data on R-6 STAND EXAM STAND DATA (Card Type 1) or R-6 STAND EXAM PLOT DATA (FPM WSBW Version) (Card Types 3 & 5) cards, according to procedures described by Hostetler (1990).

The information collected at these sites included site characteristics (slope, aspect, location, elevation) and tree characteristics (species, crown ratio, crown class, bare top, current and cumulative defoliation levels, and DBH). Crews recorded similar information on both variable radius plots and fixed radius plots. The computer program used to analyze and summarize information allows use of all data–variable radius plot and fixed radius plot–in the production of stand table summaries (personal communication with Tom Gregg, USDA Forest Service, Pacific Northwest Region, Forest Pest Management, Portland, OR).

Personnel entered all stand exam data onto the Data General computer at the Forestry and Range Sciences Laboratory, La Grande, OR. Data was analyzed with Fortran 77 programs prepared by Tom Gregg (Forest Pest Management, Portland, OR) as modules to the INFORMS Integrated Forest Management System (Anon. 1988).

## Results

Larval Sampling

We summarized lower crown sampling results for budworm larval populations by Analysis Unit, and converted to midcrown densities by the regression procedure described by Torgersen et al. [In Press].

Densities of budworm in the lower crown third ranged between 14.3 and 40.9 per 3-branch sample (Table 3). The Mill Modified and Indian Creek Analysis Units had the lowest budworm densities with each averaging slightly over 14 larvae per 3-branch sample. The Thimbleberry Analysis Unit had the highest larval populations with nearly 41 larvae per 3-branch lower crown sample. The Meacham Trail,

Mt. Emily, Kuhn-Chesnimnus, and Morgan Analysis Units had somewhat similar densities with roughly 20 larvae per 3-branch sample on each.

Pheromone Trapping

Moth captures on Analysis Units varied from 36 moths per trap on Mill Modified to almost 93 moths per trap on Kuhn-Chesnimnus (Table 4). Moth captures were relatively consistent among plots within each Analysis Unit. Standard Error of the mean for each AU was relatively low, and percent sampling error (Standard Error: Mean) never exceeded 2.0%. Confidence intervals are small for all Analysis Units; thus, the sampling means from pheromone trapping have a relatively high degree of reliability.

Pheromone trap data predicted that all Analysis Units will have heavy defoliation next year, except the Mill Modified AU, which will have moderate defoliation levels in 1992.

Because it is still in the research stages, the operational use of pheromone trap results to predict defoliation intensities may be somewhat premature. However, while we realize there may be some shortcomings with the procedure or the equation, researchers have obtained high coefficients of determination on several data sets. After using the method for several seasons, we have reasonable confidence that defoliation predictions made by this means have some measure of validity. We must weigh these results with those obtained by other means. The biological evaluation considers aerial survey mapped defoliation trends, outbreak history, current larval populations and trends, and tree damage effects, in addition to predicted defoliation. We use this information collectively to base conclusions and management implications concerning Analysis Units.

Tree Damage and Stand Characteristics

All Analysis Units contain some measure of bare or dead top and mortality of host trees (Table 5). The degree of these conditions varies, however, from AU to AU. Meacham Trail Analysis Unit contains only about one-third of the host trees per acre with no measure of bare top. Most all of the Analysis Units contain about that amount or less with no observable top damage from budworm. The proportion of host trees with bare top on nearly all Analysis Units is highest among the class of trees with 1-10 percent of the tree top bare from budworm defoliation.

The Mill Modified Analysis Unit is in striking contrast to this observation. The Mill AU contains a significantly high proportion of host trees per acre (94%; see Table 5) with no observable top damage by budworm. Half of the proportion of trees per acre with bare tops had 1-10 percent of the top bare. The other half had greater than 10 percent bare top.

Stand exam crews did not observe mortality of budworm host trees on plots taken on the Mill Modified, Kuhn-Chesnimnus, and Morgan Analysis Units (Table 5). A small amount of mortality of host trees is occurring on the other Analysis Units. On these Analysis Units, mortality varies from a low of 1 tree per acre on Meacham Trail, to 9 trees per acre on Thimbleberry.

Mostly heavy defoliation of new needles in 1991 occurred on all Analysis Units except Mill Modified (Table 6). The trees per acre with heavy defoliation (that is, >50% of the new foliage missing) ranged from 72 percent to 94 percent on all but the Mill Modified Analysis Unit. Mill Modified Analysis Unit had only 15 percent of the trees per acre showing heavy current year's defoliation. Nearly half (48%) of the trees per acre on the Mill Modified AU contained no loss of current year's foliage from bud-

worm. Other Analysis Units varied from having all trees with current year defoliation (for example, Kuhn-Chesnimnus AU), to 13 percent of the host trees per acre with undetectable current year defoliation (for example, Meacham Trail).

To measure the cumulative year's impact of budworm on Analysis Units, stand exam crews estimated the cumulative amount of foliage missing from host trees on stand exam plots. These data showed that budworm has had a measurable impact on the budworm host species within stands of all Analysis Units (Table 7). The amount of impact varies with Analysis Unit. Based upon results shown in Table 7, the heaviest impact of budworm has been to stands on the Mt. Emily Analysis Unit. Stands on the Meacham Trail, Thimbleberry, and Indian Creek Analysis Units are divided among all defoliation categories. Kuhn-Chesnimnus and Morgan Analysis Units have had mostly light and moderate amounts of foliage loss. The Mill Modified Analysis Unit contains very little loss of total foliage biomass.

The activity of bark beetles within Analysis Unit stands is indirectly a reflection of the time budworm has been present in host stands, and the degree to which defoliation has weakened stands, among other factors. The longer budworm has been present in stands, the greater the chance that damage has weakened trees making them more susceptible to bark beetles. Drought, of course, has played a significant role in tree susceptibility to bark beetle over the past several years, as well, and undoubtedly has influenced results reported in Table 8.

Douglas-fir beetle is causing a considerable impact on the Douglas-fir component of budworm susceptible stands on the Mt. Emily Analysis Unit. Douglas-fir beetles have attack nearly 40 percent of the Douglas-fir per acre on the Mt. Emily Analysis Unit (Table 8). Meacham Trail was the only other Analysis Unit with Douglas-fir beetles recorded in Douglas-firs on stand exam plots.

Most Analysis Units contained some level of fir engraver activity in the grand firs within stands (Table 8). Mill Modified and Kuhn-Chesnimnus Analysis Units were the only AUs without any bark beetle activity observed on stand exam plots. However, both fir engraver and Douglas-fir beetle activity was noted within the Kuhn-Chesnimnus Analysis Unit, after a review of the 1991 aerial insect detection survey. Probably more bark beetle activity occurs on the Analysis Units than shown by our stand examinations on the AUs.

## Discussions and Management Implications

The following is a brief discussion of the entomological sampling results on each Analysis Unit, followed by a recommendation for that Analysis Unit. Any references to percentages implies percent of host trees per acre as calculated from variable-radius plot and fixed-radius plot stand examination data, unless otherwise stated (refer to Tables 1-8).

### Meacham Trail

The outbreak of budworm on the Meacham Trail Analysis Unit started on portions of the Analysis Unit in 1985. The outbreak is now in its seventh year. Nearly 70 percent of tree species in stands on this Analysis Unit are principal budworm hosts, with over 97 percent of those hosts composed of species most vulnerable to damage from budworm (that is, grand fir and Douglas-fir). Budworm larval populations during 1991 were moderate, and pheromone trap results predict defoliation in 1992 to be heavy.

Past and present feeding by budworm on this Analysis Unit has resulted in overall moderate amounts of damage to host trees including bare top or topkill, and loss of foliage biomass. Bark beetles are becoming active in host species stands and will likely continue over time as trees are weakened by a combination of factors.

Management Implications for 1992:

I recommend that further analysis be done to determine whether direct suppression of the populations with insecticide for the Meacham Trail Analysis Unit is warranted. I expect populations to continue to remain high or increase next year, causing additional damage to trees already weakened by past defoliation and stressed by drought. With continued weakening of tree defenses, trees become more susceptible to attack by bark beetles. Trees that have diminished photosynthetic capability due to moderate and heavy foliage losses have reduced food reserves, especially starch (Van Sickle 1985, 1987). Food reserves are not only important for the health, maintenance of growth, and normal functions of trees, but also are important in the post-outbreak recovery of trees. Food reserves also serve as precursors for secondary compounds which provide natural resistance to insect attack (Hanover 1975). If defoliation continues to be heavy on the Meacham Trail Analysis Unit, food reserves of host trees may be depleted beyond the ability of trees to recover.

Several Forest Plan resource values and silvicultural projects are at risk from budworm on this Analysis Unit. Suppression of the outbreak of budworm on the Meacham Trail AU in 1992 may increase the opportunities to protect resources in the short-term and allow Ranger Districts time to carry out silvicultural projects that have long-term stand protection objectives. Treatment of the outbreak will result in reduction of budworm numbers and correspondly limit additional damage and tree mortality from budworm on this Analysis Unit. If left untreated, the outbreak is expected to continue thru 1992, which may result in unacceptable damage to timber and other resources. Bark beetles may build up further, with increased attacks on, and potential of mortality to green trees.

## Thimbleberry

The outbreak of budworm on the Thimbleberry Analysis Unit started on portions of the Analysis Unit in 1986. The outbreak is now in its sixth year. About 88 percent of the tree species in stands on this Analysis Unit are principal budworm hosts. About 89 percent of those hosts are composed of the species most vulnerable to damage from budworm (that is, grand fir and Douglas-fir). Budworm larval populations during 1991 were high, and defoliation in 1992 is predicted to be heavy. Past and present feeding by budworm on this Analysis Unit has resulted in overall moderate amounts of damage to host trees including bare top or topkill, and loss of foliage biomass. Bark beetles are beginning to become active in stands with budworm host-type. Trees weakened by a variety of causes will promote the activity of beetles in stands.

Management Implications for 1992:

I recommend that further analysis be done to determine whether direct suppression of the populations with insecticide for the Thimbleberry Analysis Unit is warranted. Populations will continue to remain high or increase next year, causing additional damage to trees weakened by defoliation and stressed by drought. With continued weakening of tree defenses, trees will become increasingly more susceptible to bark beetles. With continued defoliation, food reserves of many host trees may become depleted beyond the ability of trees to recover.

Budworm will impact various resource values and silvicultural activities on the Thimbleberry Analysis Unit. Suppression of the current budworm outbreak will protect some resources by limiting further defoliation of budworm host trees and allow the programmed implementation of projects aimed at providing long-term protection of stands from defoliators. Suppression will help to prevent significant damage and losses to mixed conifer stands from occurring over the short-term.

Treatment of budworm populations should reduce budworm to non-damaging, or negligible damage, levels and provide time to carry out silvicultural projects to improve forest health. If left untreated, the outbreak is expected to continue thru 1992, which may result in unacceptable damage to timber and other resources. Bark beetle may buildup further, with increased attacks on, and potential of mortality to green trees.

## Mill Modified

The outbreak of budworm on the Mill Modified Analysis Unit started in 1988. The outbreak is now in its fourth year. About 94 percent of the tree species in stands of this Analysis Unit are principal budworm hosts. Roughly 78 percent of those hosts are species most vulnerable to damage by budworm–grand fir and Douglas-fir. Budworm larval populations during 1991 were moderate, and pheromone trap results predicted defoliation intensity in 1992 to be moderate. In general, past and present feeding damage by budworm is light. Little bare top and cumulative defoliation has occurred. The worst damage to date is to the new foliage this year; then, only about half the trees appear to have experienced current defoliation. Stand exam plots showed no bark beetle activity; however, personal observations made on previous visits to the Ski Bluewood area within the Analysis Unit have verified that some current bark beetle activity does exist within the subalpine fir component. This bark beetle activity is associated mainly with annosus root disease caused by the fungus, *Heterobasidion annosum*, rather than with budworm defoliation.

Management Implications for 1992:

I do not believe direct suppression of the population on the Mill Modified Analysis Unit in 1992 is warranted unless additional analysis determines that resource damage will exceed levels acceptable at the present time, and there are benefits to be gained by treating. Larval populations should be monitored again in 1992, along with tree damage data collection and pheromone trapping, if warranted by larval data. A reevaluation of the Analysis Unit in 1992 should determine whether impact of budworm to resources and management objectives would justify a recommendation to treat to suppress the population in 1993. Current budworm population levels, cumulative damage, and predicted defoliation levels in 1992, are not serious enough to justify the need for treatment on the Mill Modified Analysis Unit unless expected damage will result in unacceptable impacts on resources.

Because of the elevation, species composition, moisture conditions, and other site and stand factors of the area, the Mill Modified Analysis Unit is not a "high-risk" site for budworm. The early stage of the outbreak, the relatively minor amount of damage that has occurred to date from budworm, and the relatively low to moderate susceptibility of portions of the Analysis Unit to budworm all suggest the need to defer treatment until after at least one more year of monitoring and evaluation. Suppression should be applied only if merited by entomological evidence and supported by the need to meet resource management objectives. I do not believe that the outbreak at the current stage will materially effect achieving Forest Plan objectives for the area in 1992.

Although damage to new foliage next year may be heavier than this year's, this fact alone is not enough

reason to suppress the population now. Trees will still maintain a significant amount of foliage biomass at the end of next season, and topkill or mortality should be negligible. By this winter, wind, rain, and snowstorms will have removed nearly all traces of the dry, dead, current-year foliage left by the budworm from this past summer's feeding. Damage to stands will probably be nearly imperceptible to most visitors to the area during the hunting and ski seasons this fall.

## Mt. Emily

The outbreak of budworm on the Mt. Emily Analysis Unit started on portions of the Analysis Unit in 1985. The outbreak is now in its seventh year. Over 90 percent of the tree species in stands on this Analysis Unit are principal budworm hosts. About 93 percent of those hosts are species most vulnerable to damage, and favored, by budworm–grand fir and Douglas-fir. Budworm larval populations during 1991 were moderate. Pheromone trapping results predicted defoliation in 1992 to be heavy. Past and present feeding by budworm on this Analysis Unit has resulted in mostly moderate to heavy damage to host trees. Defoliation since 1985 has resulted in 72 percent of the trees with measurable amounts of bare top or topkill, 94 percent of host trees with heavy current-year defoliation, and 89 percent of trees with moderate to heavy levels of cumulative defoliation. Bark beetle actively in stands of this Analysis Unit are highest of any of the proposed units. Douglas-fir beetles have killed over 39 percent of Douglas-firs on stand exam plots. Fir engraver beetles have killed 4 percent of the grand fir.

While the high mortality rate to Douglas-fir may seem disproportionate to that of other Analysis Units, we must consider that this magnitude of Douglas-fir beetle-caused mortality has become commonplace in many stands on the La Grande Ranger District. Bark beetles have been increasing in stands for 2 or 3 years. This is due to the length of time budworm has been in outbreak and damaging stands on the district, the poor site moisture conditions that have resulted from prolonged drought, and the proliferation of shade-tolerant grand firs and Douglas-firs which have led to overstocked stands with trees competing for limited space and resources.

From many personal observations, I firmly believe the most predictable occurrence of problems from Douglas-fir beetle, given the weakened condition of stands from defoliators, overcrowding, and drought, are to those old-growth and riparian Douglas-fir stands having a high proportion of the stand in large diameter Douglas-firs. We speculate that drought may play the most important role in tipping the balance of these stands that are predisposed to Douglas-fir beetle outbreak, in favor of the beetle. One reason for this, though speculative, might be that the Douglas-firs growing on these sites that are associated with mesic conditions along creeks and streams, are adapted to the relatively higher moisture conditions on these sites. These trees may be more sensitive to drought-induced changes to soil moisture or water table than their counter-parts growing in typically drier, shallow soil sites and in drier plant communities. Thus, soil moisture may become limiting to Douglas-firs in riparian habitats more quickly than to Douglas-firs that are more "drought-adapted," growing higher up on slopes in shallow, dry soils, along with ponderosa pines. Also, influencing the susceptibility of certain of these stands, are the various degrees and nature of site disturbances that may have occurred from use of these areas by livestock, as well as the impacts of ground-based logging equipment used in the selective harvesting of certain sites in previous years. The processes and conditions under which these stands have developed into susceptibility to bark beetles are probably much more complex than that offered here. We believe, this may be partial explanation; other possible explanations undoubtedly have merit as well.

Management Implications for 1992:

I recommend that further analysis be done to determine whether direct suppression of the budworm population with insecticide for the Mt. Emily Analysis Unit is warranted. I expect populations to continue to remain high or increase next year, causing additional damage to trees already weakened by past defoliation and stressed by drought. Budworm defoliation will continue to weaken trees in these stands. With continued weakening of tree defenses, trees will become more susceptible to attack by bark beetles. Left untreated, bark beetles will rapidly increase in stands with weakened trees, causing loss to larger host tree components of stands. While this may temporarily increase the proportion of non-host species in stands, ultimately the shade-tolerant species will reinvade sites, and will once again develop to stands having high susceptibility to budworm, unless silviculture and fire are used to control stocking, species composition, and stand structure.

Continuing heavy defoliation of trees on the Mt. Emily Analysis Unit will result in poor condition of stands. Trees with diminished energy reserves will be reduced further in their ability to sustain themselves, and they may die outright from defoliation injury, or have greater difficulty in recovering once the outbreak subsides.

Budworm defoliation will impact resource values of the area. Several active and proposed silvicultural projects are aimed at long-term reduction of forest and stand susceptibility to the budworm. These will occur within the next five years. Suppression of budworm populations in 1992, should buy some time to carry out these projects before much of the value of stands is lost to budworm through increased topkill, mortality, growth losses, and stem defects.

## Indian Creek

The outbreak of budworm on the Indian Creek Analysis Unit started on portions of the area in 1980. The outbreak on parts of this unit is now in the twelfth year. This AU contains the oldest areas of outbreak of any of the Analysis Units. About 85 percent of the trees on this AU are principal budworm hosts. About 59 percent of these trees are hosts which typically are severely damaged or killed by budworm (that is, grand fir and Douglas-fir). Budworm larval populations during 1991 were moderate, and pheromone trapping results predict heavy defoliation of host trees in 1992. Overall effects of past and present feeding by budworm have resulted in moderate injury to stands. Over 80 percent of host trees have some degree of bare top or topkill. Current defoliation in 1991 was mostly heavy, but the cumulative defoliation to date is mostly light (50 percent of the trees). Only 19 percent of the trees were recorded with moderate levels of missing foliage, and 14 percent had heavy cumulative defoliation. Bark beetle activity was noted only for the grand fir component on stand exam plots.

Management Implications for 1992:

I recommend that further analysis be done to determine whether direct suppression of the budworm population with insecticide on the Indian Creek Analysis Unit in 1992 is warranted. Populations will remain high or increase next year, causing additional damage to trees previously weakened by defoliation and stressed by drought. Bark beetles will become an increasingly important mortality factor on this Analysis Unit in the next few years, as trees are defoliated by budworm and impacted by drought. Even though stand exam data shows moderate levels of cumulative damage to stands overall, the length of time budworm has been impacting stands, along with drought stress, will eventu-

ally take their toll in degrading energy reserves and tree defenses. The poor vigor stands are more vulnerable to losses by secondary insects.

Several resource values are at risk from budworm. Direct suppression of budworm will protect some of these resources by limiting further defoliation over the short-run. Much of the Indian Creek Analysis Unit includes either active or planned silvicultural projects with the long-term objectives of reducing budworm habitat and sustaining vigorous forest growth by increasing the composition of ponderosa pine, western larch, and lodgepole pine in stands, and thinning to regulate stand density and improve tree vigor. Time will be needed over the next five years to carry out these activities. Unchecked budworm populations will diminish stand values and may cause some plans to be postponed or abandoned. Suppression of the budworm outbreak should allow these plans to proceed as scheduled.

## Kuhn-Chesnimnus

The outbreak of budworm on the Kuhn-Chesnimnus Analysis Unit started on portions of the Analysis Unit in 1986. The outbreak is now in its sixth year. This Analysis Unit contains 76 percent of the trees in budworm host type, and over 98 percent of these species are grand fir and Douglas-fir, with Douglas-fir occurring in the greatest proportion in mixed conifer stands. Budworm larval populations during 1991 were moderate relative to other Analysis Units. Pheromone trapping predicted defoliation in 1992 to be heavy. Past and present feeding damage by budworm on this Analysis Unit has resulted in nearly all trees experiencing measurable amounts of bare tops or topkill. Only 4 percent of the trees on plots had no detectable top damage. Current-year foliage loss to budworm in 1991 was heavy, and virtually all trees on plots contained mostly light to moderate amounts of cumulative defoliation. Bark beetle activity on the area, although not recorded on stand exam plots, does occur in some Analysis Unit stands based on the results of the 1991 aerial insect detection survey.

Management Implications for 1992:

I recommend the further analysis be done to determine whether direct suppression of the budworm outbreak with insecticide on the Kuhn-Chesnimnus Analysis Unit in 1992 is warranted. I expect populations to continue to remain high or increase next year, causing additional damage to trees already weakened by past defoliation and stressed by drought. With unchecked budworm populations, continued defoliation and drought will further weaken tree defenses, reducing their ability to overcome attacks by secondary bark beetles. Bark beetles will increase in the low vigor stands and cause losses beyond budworm alone.

Continuing losses of foliage by budworm will reduce affected trees ability to photosynthesize, and may lead to depletion of starch reserves as these are used up and not replaced. Trees in this condition may not be able to sustain themselves through the remainder of the outbreak, or will take longer to recover following the outbreak.

Several resource values and active or proposed projects are at risk of damage or deferment due to the budworm outbreak. Several silvicultural projects that have long-term implications to the management of budworm, and to forest and stand health, will occur within the next five years. Certain activities such as thinning over-stocked Douglas-fir stands would likely be deferred if populations were not suppressed, since we do not recommend thinning stands during an outbreak. Suppression of populations with insecticide would provide some protection of resources for the short-term, and would permit proposed silvicultural treatments in the 92 through 96 timber sales to proceed without de-

lay. Ultimately, budworm suppression in 1992 should help the district to achieve Forest Plan resource management objectives on the Kuhn-Chesnimnus Analysis Unit.

### Morgan

The outbreak of budworm on the Morgan Analysis Unit started on portions of the unit in 1986, The outbreak is now in its sixth year. Roughly 81 percent of the tree species in stands on this Analysis Unit are principal budworm hosts. Over 97 percent of those hosts are grand fir and Douglas-fir. These species are the most seriously damaged during budworm outbreaks. Nearly two-thirds of the stands are grand fir. Budworm larval populations during 1991 were moderate, relative to other Analysis Units. Pheromone trapping results predicted defoliation in 1992 to be heavy. About 62 percent of the host trees in stand exam plots contain bare tops, mostly in the top 10 percent of the crown. Current-year defoliation has been heavy, and cumulative loss of foliage was mostly light to moderate. Overall, past and present budworm damage to stands on the Morgan Analysis Unit is moderate. The Analysis Unit had a minor amount of bark beetle damage within stands; however, Engelmann spruce stands in most of the drainages have been decimated by the spruce beetle outbreak over the past decade. The western spruce budworm, and secondary bark beetles, are major threats to these severely hit stands. In some cases, all that remains protecting stream temperatures through limited shading are budworm-infested trees and whatever low-growing shrubs occur along streamsides.

Management Implications for 1992:

I recommend that further analysis be done to determine whether direct suppression of the populations with insecticide on the Morgan Analysis Unit in 1992 is warranted. I expect insect populations to remain high or increase next year, causing additional damage to trees in stands already weakened by several years of defoliation by budworm, those that are drought-stressed, and those debilitated by spruce beetles. If the budworm outbreak is unchecked, defoliation will impair photosynthetic ability, weaken tree defenses, and further lower tree energy reserves. This action would result in increasing the susceptibility of weakened trees to bark beetles and could lead to build up of beetles to outbreak levels, resulting in higher levels of tree mortality, and poor recovery of surviving host trees after the outbreak.

Suppression of the budworm outbreak in 1992 would help to check insect damage to stands and protect resources on the Analysis Unit. Several silvicultural projects that are active or planned within the next 5 years will be able to proceed as scheduled. These activities (proposed timber sales and thinning projects) will provide long-term management of the budworm and improved tree growth, vigor, and stand and forest health by increasing the composition of ponderosa pine, western larch, and lodgepole pine in the stands, and regulating stand density. Delay of these treatments due to lack of budworm suppression would prolong the stands susceptibility to budworm infestation and would also have a direct impact on the proposed timber harvest volumes for these projects. Lack of treatment on the Morgan Analysis Unit might compromise Forest Plan resource management objectives for this area.

## Summary

The outbreak of western spruce budworm has become widespread in the Blue Mountains in the last several years. It encompasses nearly all mixed conifer stands containing budworm host species, especially grand fir and Douglas-fir, in a vast number of locations in northeast Oregon and southeast

Washington. Accordingly, managers of the Walla Walla Ranger District, Umatilla National Forest, and the La Grande and Wallowa Valley Ranger Districts, Wallowa-Whitman National Forest, undertook a project to study the budworm situation, and the need for suppression of populations, in specific areas (Analysis Units) on their respective districts. Suppression, should it be determined necessary, would be by insecticide treatment using the biological insecticide, *Bacillus thuringiensis* (*B.t.*).

The western spruce budworm Analysis Units on the Umatilla and Wallowa-Whitman National Forests proposed for possible insecticide treatment to suppress budworm populations in 1992, contain a multitude of resource values that are at various degrees of risk of being damaged by budworm. Direction for the management of these resources is in the Land and Resource Management Plans (Forest Plans) for the Umatilla and Wallowa-Whitman National Forests. Standards and guidelines for the treatment to suppress defoliator populations such as budworm, when these insects threaten to cause damage at levels which interfere with achieving resource management objectives, is also in the Forest Plans.

We have undertaken the evaluation of budworm populations, tree damage, and potential for future damage to stands, for each Analysis Unit using the best procedures now available. Results of this evaluation has indicated that suppression of budworm populations on 6 of the 7 proposed Analysis Units may be beneficial. The Mill Modified Analysis Unit probably would not incur serious damage if budworm populations were left untreated for reasons stated in the previous sections.

Although suppression of insect populations on a large portion of the 278,614 combined acres within Analysis Units will reduce insect numbers, and reduce damage to trees and resource values, the effects achieved will be short-lived. From past experience, we do not expect reductions of budworm populations to last longer than 3 or 4 years. Resurgence of the populations or reinvasion of budworm from adjacent untreated areas will occur over time.

Treatment of budworm populations with insecticides does nothing to alter the composition and characteristics of stands that make these areas favored habitat for budworm. Population reductions can be achieved on a long-term basis through the appropriate use of silvicultural methods. Such methods should be designed to reduce stocking of budworm host species by selecting against the shade-tolerant true firs and Douglas-fir, and favoring of non-host seral ponderosa pine, lodgepole pine, and western larch. The methods prescribed should alter stand structure of mixed conifer stands to achieve a single canopy layer. In addition, methods should be used to regulate stand density to avoid overcrowding and poor tree vigor, and to improve stand growth. In essence, we should utilize any techniques that will reduce budworm habitat and sustain vigorous forest growth.

Without the reduction or elimination of budworm host species in stands, and the regular maintenance of stand conditions through use of prescribed fire and thinning to avoid the reinvasion of stand understories by shade-tolerant host species, resistance of stands to budworm cannot be maintained for the long-term. Silvicultural manipulation of vegetation on the Analysis Units is necessary to avoid future episodes of damaging budworm outbreaks; to improve tree vigor and stand growth; to provide long-term protection of resources to meet Forest Plan resource management objectives and achieve Desired Future Condition; and to improve overall forest health by mimicking natural forest ecosystem processes.

Numerous projects designed to accomplish the above, are planned on portions of just about all of the Analysis Units. I encourage these types of cultural activities for other areas of the Analysis Units where appropriate, as well.

### Acknowledgements

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Several Ranger District personnel provided invaluable help in delineating Analysis Units and identifying potential treatment areas and resource management objectives for the Analysis Units. I gratefully acknowledge the help of Gary Rollins and Nancy Berlier of the Walla Walla Ranger District; Ken Rockwell and Julie Baird of the La Grande Ranger District; and Dave Little and Miscese Gagen of the Wallowa Valley Ranger District.

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Finally, I thank Jennifer Watson, Forestry and Range Sciences Lab, La Grande, for typing the report and her patience in making the many changes and corrections.

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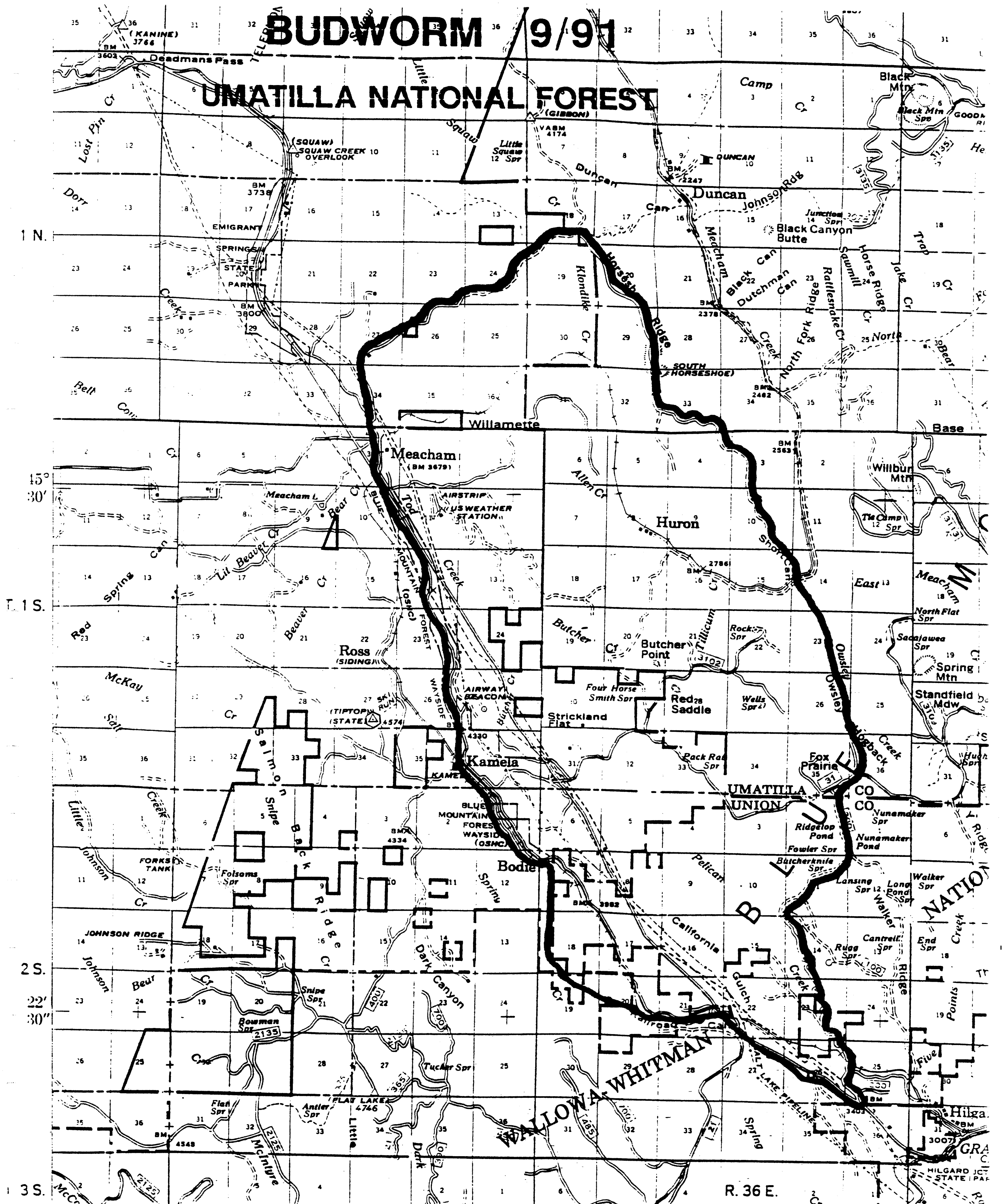
Submitted By: *[signature]* Date: November 15, 1991

## Appendix A–Maps of Analysis Units

# MEACHAM-TRAIL ANALYSIS AREA

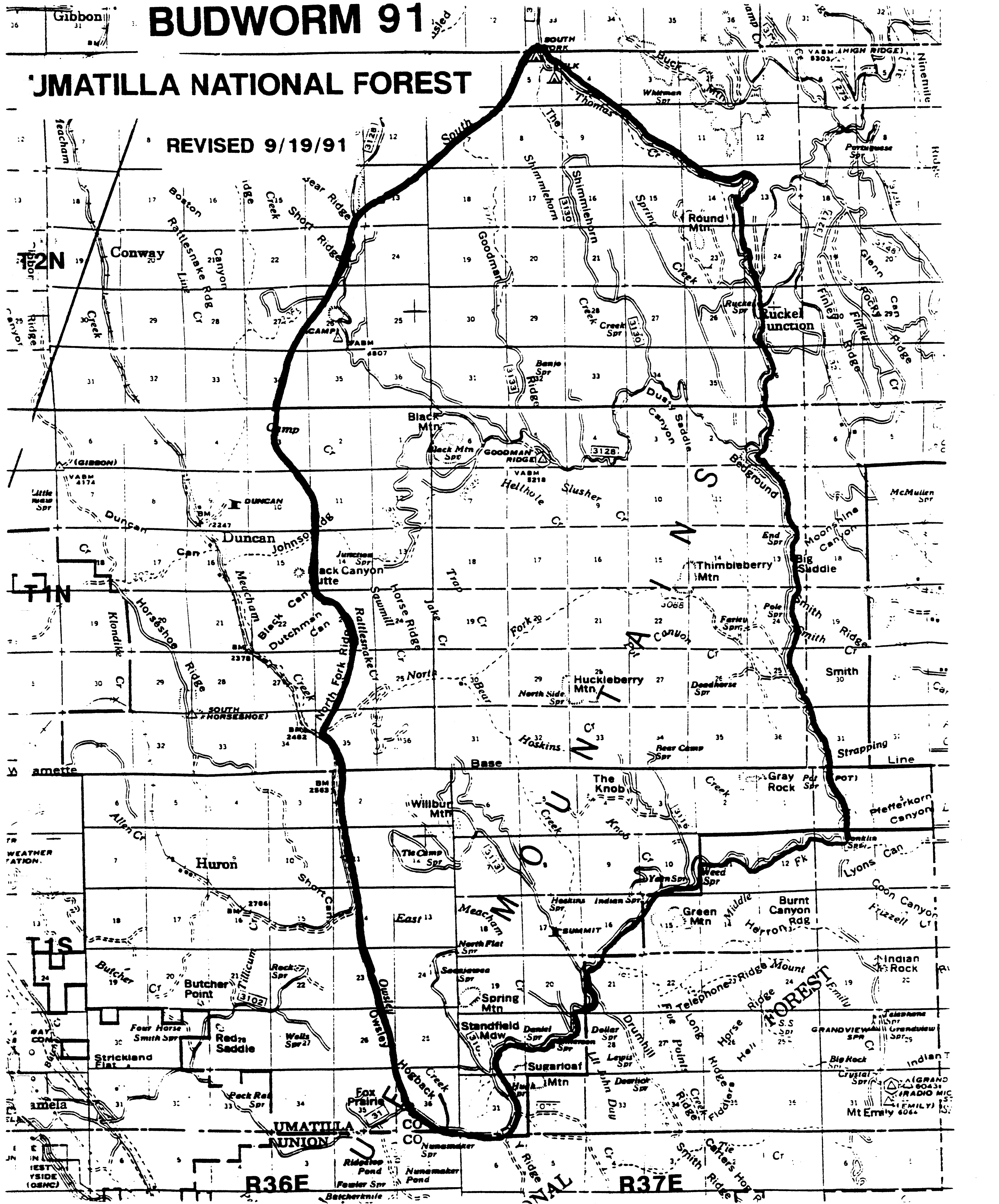


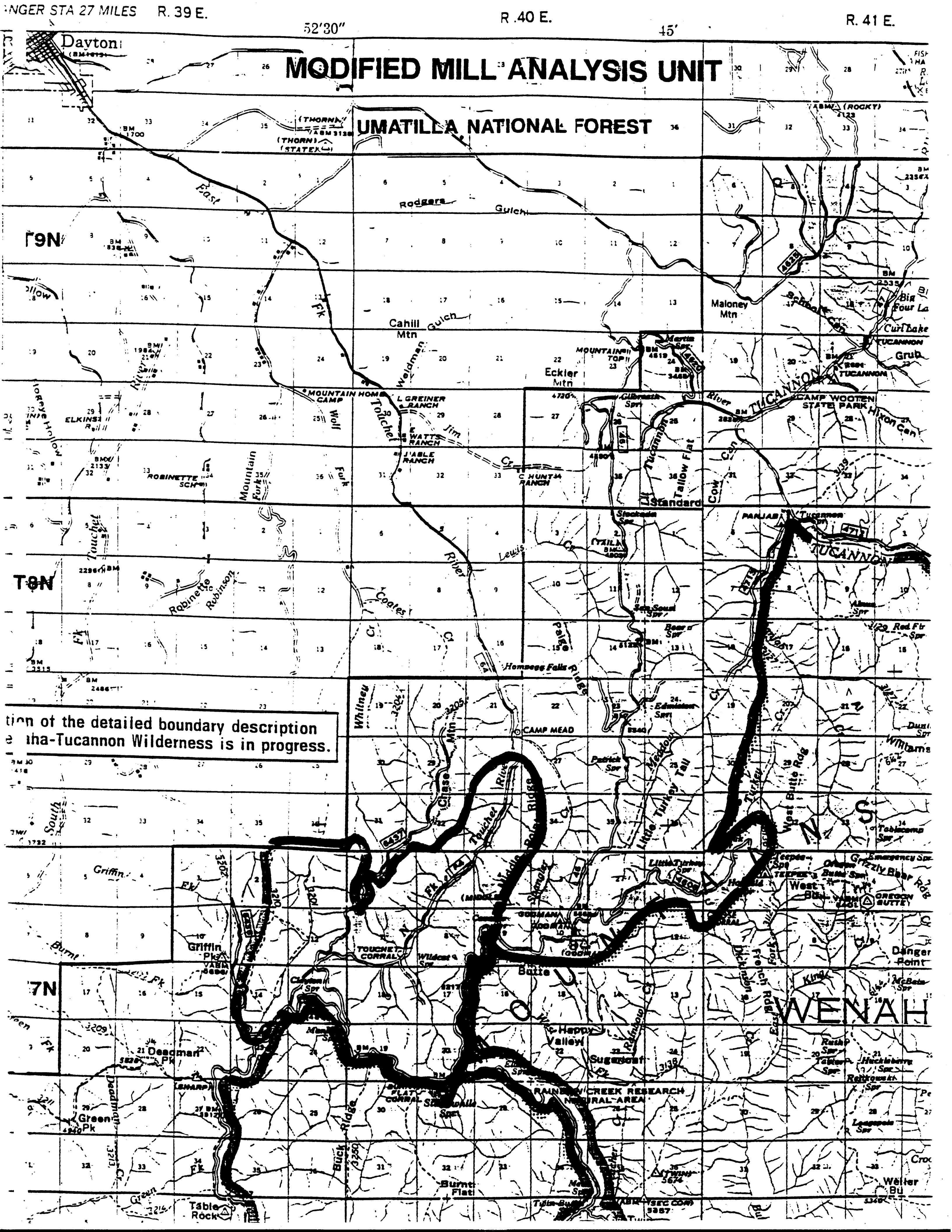
# THIMBLEBERRY ANALYSIS AREA

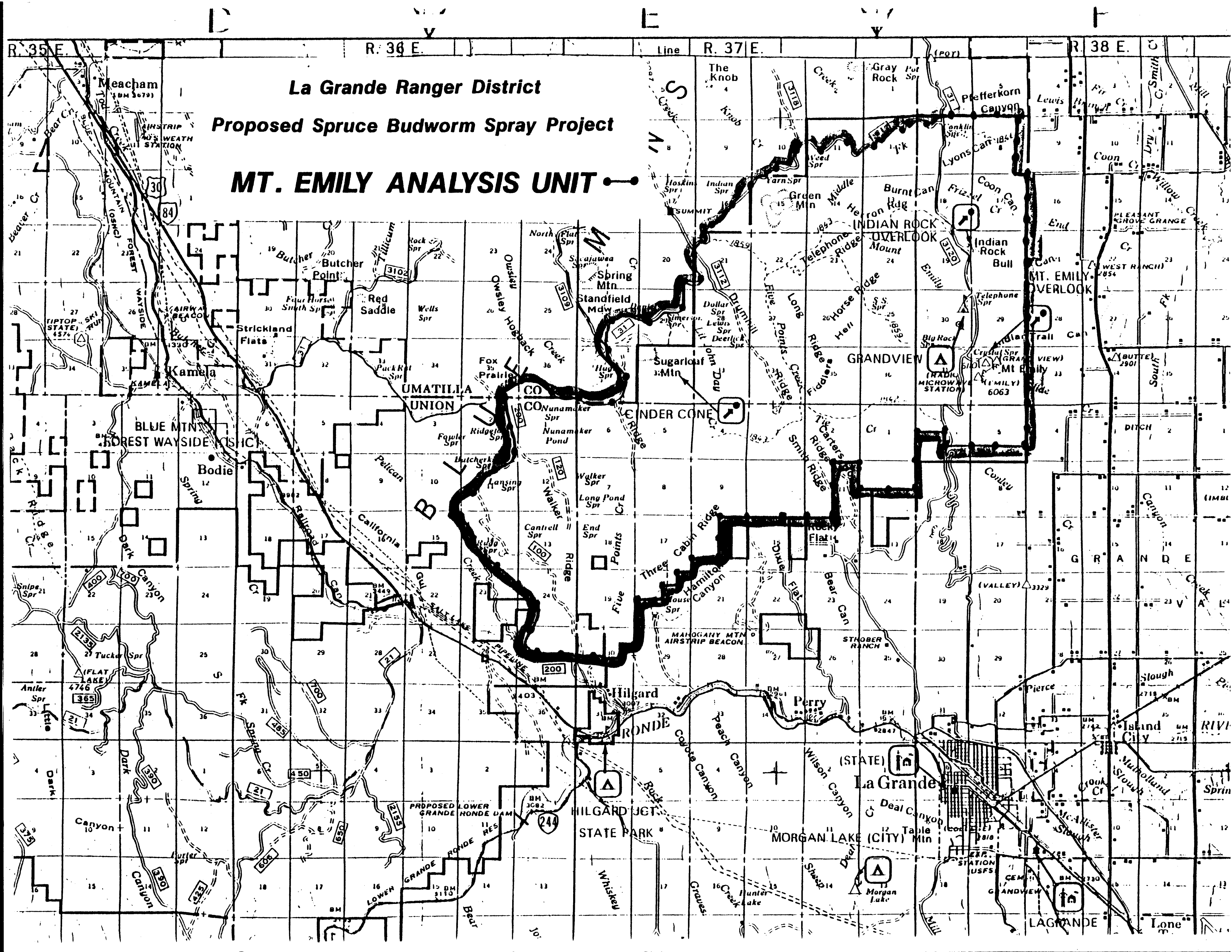
## BUDWORM 91

## UMATILLA NATIONAL FOREST

REVISED 9/19/91




MODIFIED MILL ANALYSIS UNIT
UMATILLA NATIONAL FOREST
tion of the detailed boundary description
e aha-Tucannon Wilderness is in progress.
NGER STA 27 MILES
R. 39 E.
R. 40 E.
R. 41 E.
52'30"
45'
T9N
T8N
T7N
Dayton
East Fk
Touchet River
Rodgers Gulch
Cahill Mtn
Eckler Mtn
Maloney Mtn
Big Four Lake
Curl Lake
Tucannon
Grub
MOUNTAIN HOME CAMP
L GREINER RANCH
E WATTS RANCH
J'ABLE RANCH
C HUNT RANCH
ROBINETTE SCH
ELKINS
CAMP WOOTEN STATE PARK
Tucannon River
Standard
Panjab
Lewis Cr
Coates Cr
Robinette
Robinson
CAMP MEAD
Hompegg Falls Ridge
Whitney
Griffin
Griffin Pk
Burnt
Touchet Corral
Wildcat Spr
Godman
Butte
Happy Valley
Sugarloaf
RAINBOW CREEK RESEARCH NATURAL AREA
West Butte Rdg
Teepee Spr
Oregon Butte
Danger Point
Grizzly Bear Rdg
WENAH
Deadman Pk
Green Pk
Table Rock
Burnt Flat
Buck Ridge
Weller Bu

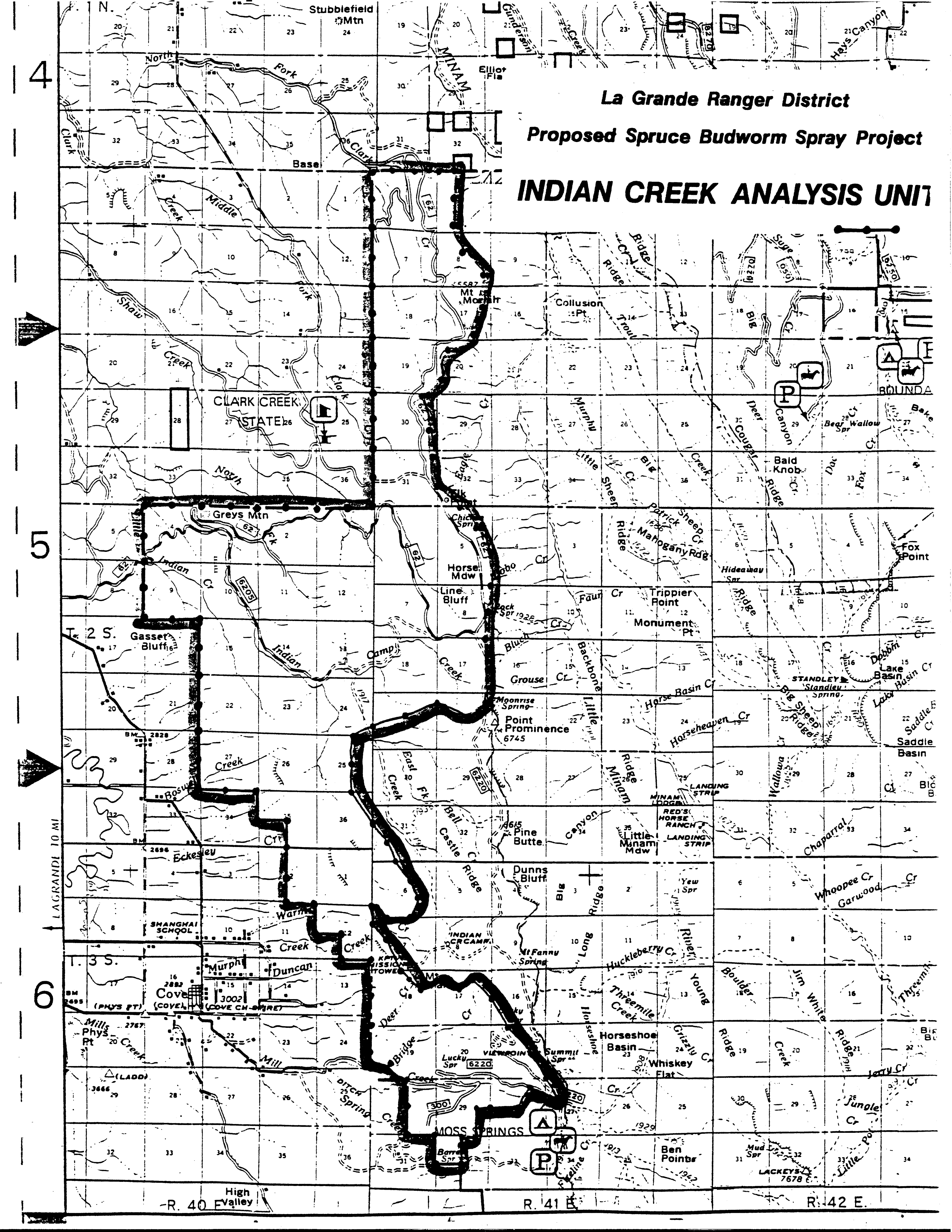


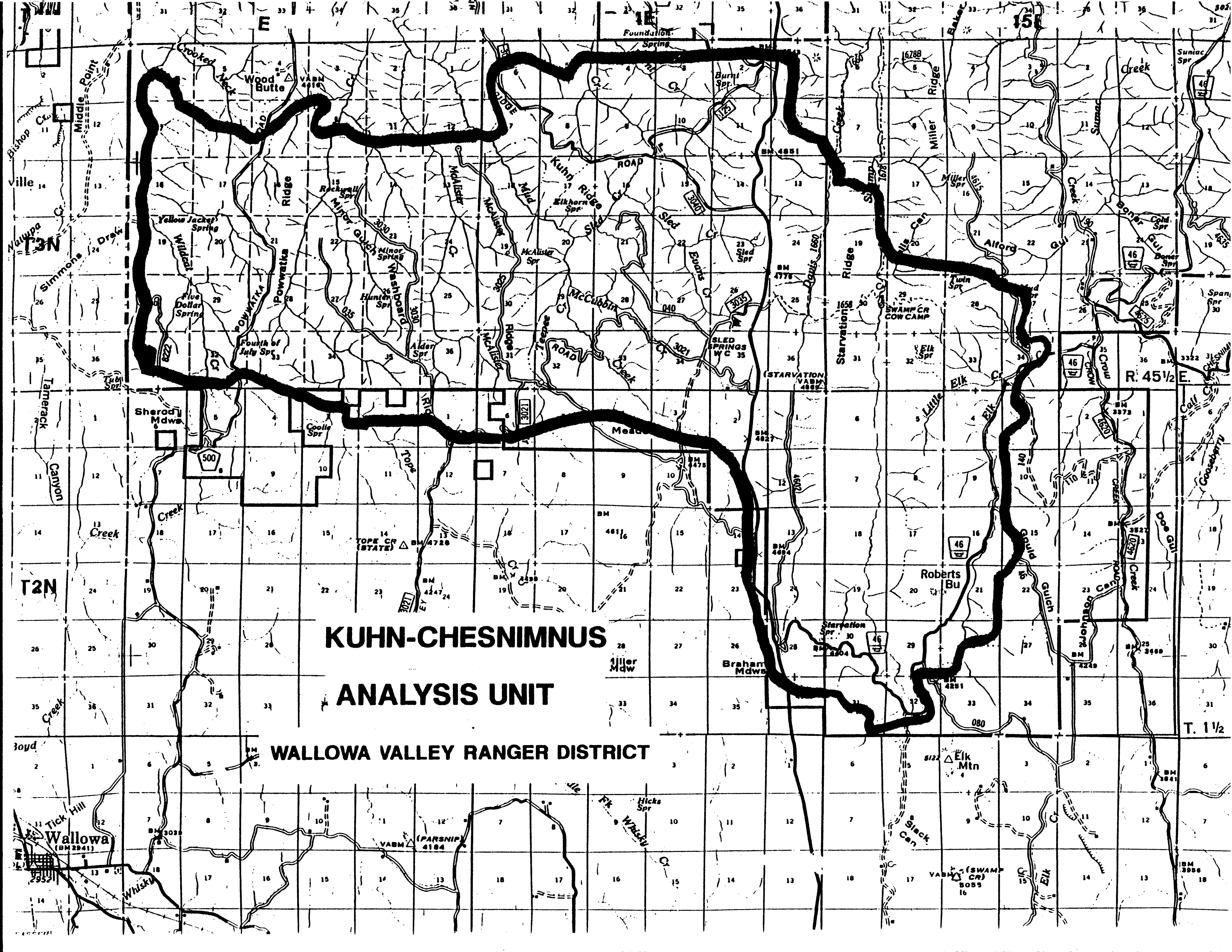
La Grande Ranger District
Proposed Spruce Budworm Spray Project
MT. EMILY ANALYSIS UNIT
R. 35 E.
R. 36 E.
R. 37 E.
R. 38 E.
Meacham
Kamela
BLUE MTN FOREST WAYSIDE (OSHC)
Bodie
Strickland Flats
Butcher Point
Red Saddle
Fox Prairie
UMATILLA CO
UNION CO
Spring Mtn
Standfield Mdw
Sugarloaf Mtn
CINDER CONE
The Knob
Gray Rock
Pfefferkorn Canyon
Green Mtn
INDIAN ROCK OVERLOOK
Indian Rock
MT. EMILY OVERLOOK
GRANDVIEW
Mt Emily 6063
Three Cabin Ridge
Hamilton Canyon
Rock Flat
MAHOGANY MTN AIRSTRIP BEACON
STROBER RANCH
Hilgard
Perry
La Grande
Island City
HILGARD JCT STATE PARK
PROPOSED LOWER GRANDE RONDE DAM
MORGAN LAKE (CITY)
Table Mtn
GRANDE RONDE
LAGRANDE

# La Grande Ranger District

## Proposed Spruce Budworm Spray Project

# INDIAN CREEK ANALYSIS UNIT




KUHN-CHESNIMNUS
ANALYSIS UNIT
WALLOWA VALLEY RANGER DISTRICT
T3N
T2N
R. 45 1/2 E.
T. 1 1/2
Foundation Spring
Wood Butte
Crooked
Neck
Middle Point
Bishop Cr
Simmons Draw
Yellow Jacket Spring
Wildcat
Five Dollar Spring
Powwatka
Ridge
Fourth of July Spr
Rockwall Spr
Minor Gulch
Minor Spring
Washboard
Hunter Spr
Alder Spr
McAlister
McAlister Spr
Mud
Kuhn Ridge
ROAD
Elkhorn Spr
Sled
Sled Spr
Evans Cr
McCubbin
Teepee Cr
Creek
SLED SPRINGS W C
(STARVATION)
Burnt Spr
Davis
Starvation
Ridge
SWAMP CR COW CAMP
Twin Spr
Elk Spr
Little Elk Cr
Miller Ridge
Miller Spr
Alford Gul
Boner Gul
Cold Spr
Sumac
Sunac Spr
Crow
Gooseberry
Doe Gul
Gould
Gulch
Johnson Can
Roberts Bu
Starvation Spr
Braham Mdws
Miller Mdw
Sherod Mdws
Coolie Spr
Tope
TOPE CR (STATE)
Tamarack
Canyon
Creek
Boyd
Tick Hill
Wallowa
Whisky
Fk Whisky Cr
Hicks Spr
(PARSNIP)
Elk Mtn
Slack Can
(SWAMP CR)
Elk

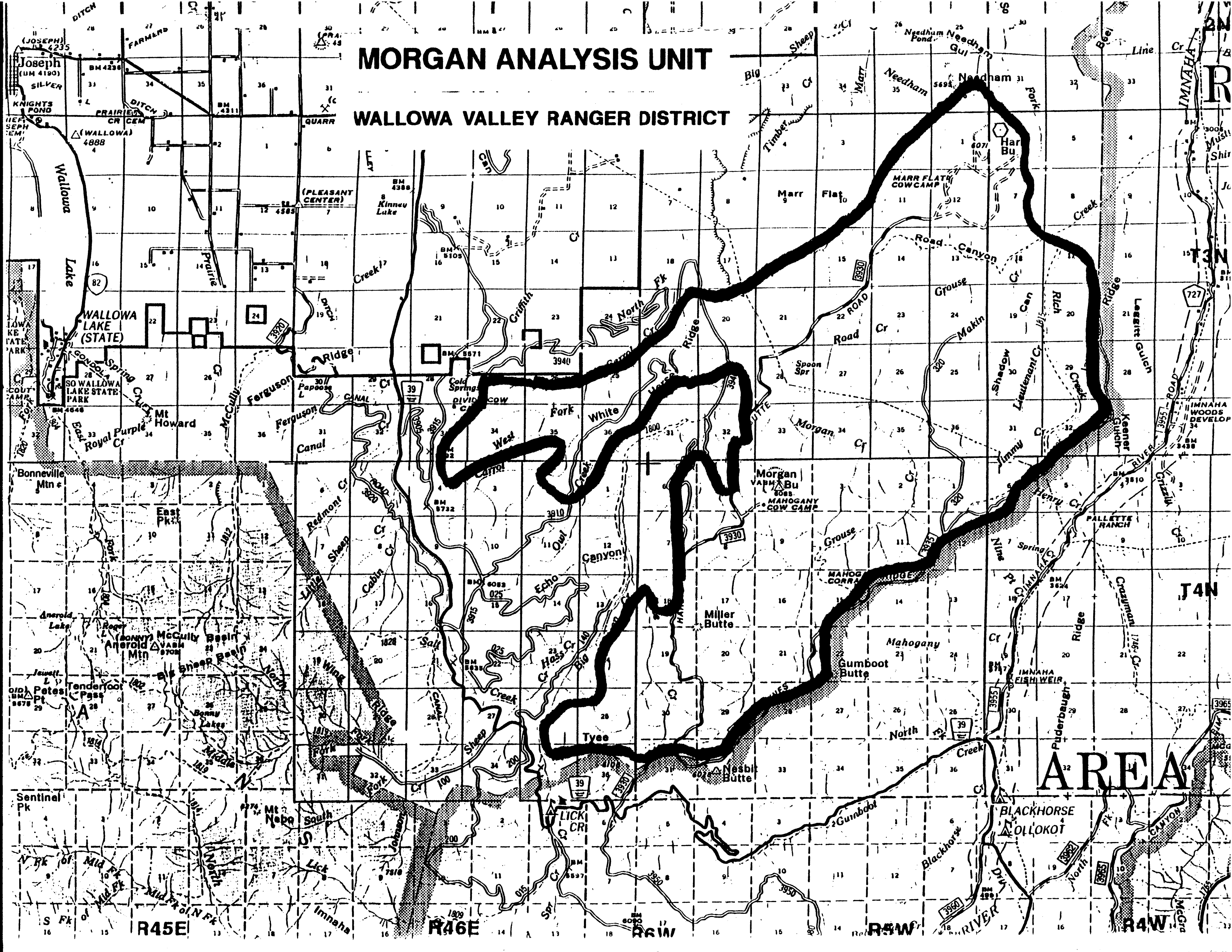

MORGAN ANALYSIS UNIT
WALLOWA VALLEY RANGER DISTRICT
AREA

Table 1. Years western spruce budworm defoliation has been visible from the air on Analysis Units on the Umatilla and Wallowa-Whitman National Forests, during the current outbreak.[1]

| *Analysis Unit* | *Ranger District* | *Years Defoliation Visible* | *Year Outbreak Started* |
|---|---|---|---|
| Meacham Trail | Walla Walla/La Grande | 7 | 1985 |
| Thimbleberry | Walla Walla | 6 | 1986 |
| Mill Modified | Walla Walla | 4 | 1988 |
| Mt. Emily | La Grande | 7 | 1985 |
| Indian Creek | La Grande | 12 | 1980 |
| Kuhn-Chesnimnus | Wallowa Valley | 6 | 1986 |
| Morgan | Wallowa Valley | 6 | 1986 |

[1] Data based on Aerial Insect Detection Survey conducted annually by Forest Pest Management, Pacific Northwest Region, Portland, Oregon.

Table 2. Distribution of western spruce budworm host trees per acre on Analysis Units on the Umatilla and Wallowa-Whitman National Forests, 1991[1].

| *Analysis Unit* | *Ranger District* | *Percent of Host Trees per Acre[2]* Grand fir | Douglas-fir | Subalpine Fir | Engelmann Spruce |
|---|---|---|---|---|---|
| Meacham Trail | Walla Walla/La Grande | 39.1 | 29.0 | 1.2 | 0.6 |
| Thimbleberry | Walla Walla | 48.0 | 30.3 | 8.1 | 1.2 |
| Mill Modified | Walla Walla | 57.8 | 15.6 | 20.2 | 0.2 |
| Mt. Emily | La Grande | 57.6 | 26.7 | 0.4 | 5.9 |
| Indian Creek | La Grande | 49.3 | 10.1 | 12.2 | 13.2 |
| Kuhn-Chesnimnus | Wallowa Valley | 29.1 | 46.1 | 0.1 | 1.1 |
| Morgan | Wallowa Valley | 65.1 | 13.8 | 0.5 | 1.7 |

[1] Data from stand examinations conducted during August and September 1991 on Analysis Units.

[2] For the purpose of this analysis, principal budworm host tree species include: grand fir or white fir, subalpine fir, Douglas-fir, and Engelmann spruce. Though western larch is considered a host for budworm, defoliation damage to larch in the Blue Mountains is considered inconsequential to the health of larch, or to the health of stands within which larch occurs. Thus, larch is not included here as a host tree for the purposes of this analysis.

Table 3. Average numbers of western spruce budworm larvae per tree (3-branch sample) from lower crown sampling of Analysis Units, and estimated midcrown densities, on the Umatilla and Wallowa-Whitman National Forests, 1991.

| | | | *Budworm Density (mean ± SE)*[1] | |
|---|---|---|---|---|
| *Analysis Unit* | *Ranger District* | *No. of Plots* | *Larvae per 3-branch Lower Crown Sample* | *Larvae per 18-inch Midcrown Branchtip* |
| Meacham Trail | Walla Walla/La Grande | 57 | 20.6 ± 1.04 | 14.32 |
| Thimbleberry | Walla Walla | 40 | 40.9 ± 2.63 | 28.08 |
| Mill Modified | Walla Walla | 40 | 14.3 ± 2.26 | 10.05 |
| Mt. Emily | La Grande | 7 | 20.4 ± 2.56 | 14.18 |
| Indian Creek | La Grande | 64 | 14.6 ± 0.77 | 10.25 |
| Kuhn-Chesnimnus | Wallowa Valley | 40 | 21.6 ± 1.80 | 15.00 |
| Morgan | Wallowa Valley | 40 | 19.9 ± 1.32 | 13.84 |

[1] Conversion of Lower Crown Beating (LCB) means to midcrown densities based upon regression equation: Midcrown Density = 0.3513 + 0.6781 (LCB); (Torgersen et al 1991). Standard Errors (SE) could not be reported for converted means.

Table 4. Predicted 1992 defoliation levels from average numbers of western spruce budworm adults per pheromone trap captured in 1991 on Analysis Units on the Umatilla and Wallowa-Whitman National Forests.

| *Analysis Unit* | *Ranger District* | *No. of Traps* | *Mean ± SE Adult per Trap* | *Predicted 1992 Defoliation*[1] |
|---|---|---|---|---|
| Meacham Trail | Walla Walla/La Grande | 64 | 65.12 ± 0.93 | H |
| Thimbleberry | Walla Walla | 37 | 48.72 ± 1.00 | H |
| Mill Modified | Walla Walla | 30 | 36.03 ± 0.60 | M |
| Mt. Emily | La Grande | 30 | 79.31 ± 0.78 | H |
| Indian Creek | La Grande | 60 | 63.83 ± 0.35 | H |
| Kuhn-Chesnimnus | Wallowa Valley | 41 | 92.87 ± 1.19 | H |
| Morgan | Wallowa Valley | 40 | 50.08 ± 0.46 | H |

[1] Based on personal communication with Charles Sartwell, USDA Forest Service, PNW Research Station, retired. (M = stands moderately defoliated; H = heavy defoliation either in upper crowns or of entire crowns.)

Table 5. Percent of host trees per acre with western spruce budworm-caused top damage or mortality on Analysis Units on the Umatilla and Wallowa-Whitman National Forests, 1991[1].

| | | Percent of Host Trees per Acre Affected | | | |
|---|---|---|---|---|---|
| | | | 1 - 10% | > 10% | |
| *Analysis Unit* | *Ranger District* | *Green* | *Bare Top* | *Bare Top* | *Dead* |
| Meacham Trail | Walla Walla/La Grande | 34 | 38 | 27 | 1 |
| Thimbleberry | Walla Walla | 10 | 69 | 12 | 9 |
| Mill Modified | Walla Walla | 94 | 3 | 3 | 0 |
| Mt. Emily | La Grande | 23 | 49 | 23 | 5 |
| Indian Creek | La Grande | 15 | 64 | 19 | 2 |
| Kuhn-Chesnimnus | Wallowa Valley | 4 | 84 | 12 | 0 |
| Morgan | Wallowa Valley | 38 | 56 | 6 | 0 |

[1] Data from stand examinations conducted during August and September 1991 on Analysis Units.

Table 6. Percent of host trees per acre with western spruce budworm-caused defoliation of current year's foliage, by defoliation class, on Analysis Units on the Umatilla and Wallowa-Whitman National Forests, 1991[1].

| | | Percent of Host Trees per Acre Affected[2] | | | |
|---|---|---|---|---|---|
| *Analysis Unit* | *Ranger District* | *None* | *Light* | *Moderate* | *Heavy* |
| Meacham Trail | Walla Walla/La Grande | 13 | 2 | 13 | 72 |
| Thimbleberry | Walla Walla | 11 | 4 | 0 | 85 |
| Mill Modified | Walla Walla | 48 | 15 | 22 | 15 |
| Mt. Emily | La Grande | 6 | 0 | 0 | 94 |
| Indian Creek | La Grande | 3 | 3 | 12 | 81 |
| Kuhn-Chesnimnus | Wallowa Valley | 0 | 10 | 10 | 80 |
| Morgan | Wallowa Valley | 12 | 2 | 4 | 82 |

[1] Data from stand examinations conducted during August and September 1991 on Analysis Units.

[2] Current defoliation levels based upon the following amounts of missing new foliage: Light = $> 0 < 25\%$; Moderate = $> 25\% \leq 50\%$; Heavy = $> 50\%$.

Table 7. Percent of host trees per acre with western spruce budworm-caused cumulative defoliation (all previous year's defoliation in addition to the current year's defoliation), by defoliation class, on Analysis Units on the Umatilla and Wallowa-Whitman National Forests, 1991[1].

| *Analysis Unit* | *Ranger District* | *Percent of Host Trees per Acre Affected*[2] | | | |
|---|---|---|---|---|---|
| | | *None* | *Light* | *Moderate* | *Heavy* |
| Meacham Trail | Walla Walla/La Grande | 17 | 35 | 20 | 28 |
| Thimbleberry | Walla Walla | 11 | 24 | 39 | 26 |
| Mill Modified | Walla Walla | 87 | 8 | 3 | 2 |
| Mt. Emily | La Grande | 5 | 6 | 21 | 68 |
| Indian Creek | La Grande | 17 | 50 | 19 | 14 |
| Kuhn-Chesnimnus | Wallowa Valley | 0 | 67 | 29 | 4 |
| Morgan | Wallowa Valley | 13 | 62 | 21 | 4 |

[1] Data from stand examinations conducted during August and September 1991 on Analysis Units.

[2] Current defoliation levels based upon the following amounts of cumulative year's of missing foliage: Light = > 0 ≤ 25%; Moderate = > 25% ≤ 50%; Heavy = > 50%.

Table 8. Percent of western spruce budworm host trees per acre killed by bark beetles on Analysis Units on the Umatilla and Wallowa-Whitman National Forests, 1991[1].

| | | *Percent of Host Trees per Acre Affected*[2] | | | |
|---|---|---|---|---|---|
| *Analysis Unit* | *Ranger District* | *Grand fir* | *Douglas-fir* | *Subalpine fir* | *Engelmann Spruce* |
| Meacham Trail | Walla Walla/La Grande | 31.6 | 18.6 | | 15.3 |
| Thimbleberry | Walla Walla | 2.1 | | | |
| Mill Modified | Walla Walla | | | | |
| Mt. Emily | La Grande | 4.1 | 39.2 | | |
| Indian Creek | La Grande | 3.2 | | | |
| Kuhn-Chesnimnus | Wallowa Valley | | | | |
| Morgan | Wallowa Valley | 0.1 | | | |

[1] Data from stand examinations conducted during August and September 1991.

[2] Primary bark beetle species attacking host trees include the following: grand fir = fir engraver; Douglas-fir = Douglas-fir beetle; subalpine fir = western balsam bark beetle, *Pseudohylesinus tsugae*, fir engraver and other Scolytus spp.; Engelmann spruce = spruce beetle, *Dryocoetes* spp., *Ips* spp. and possibly other species.

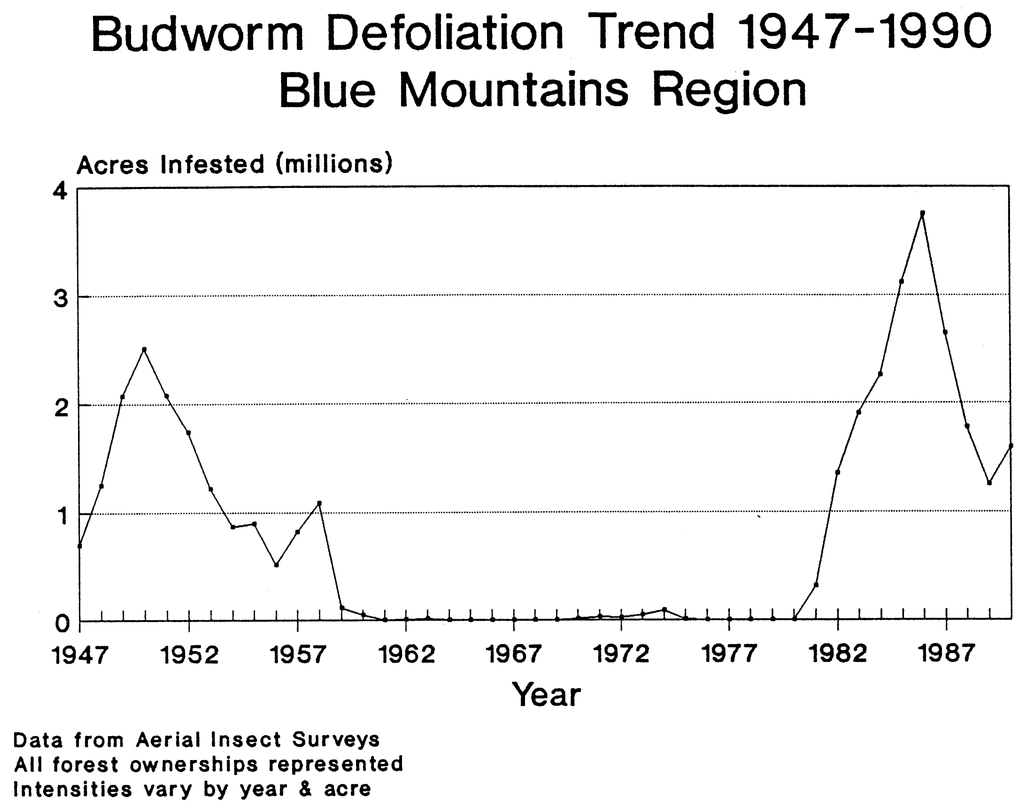



**Figure 1.** Western spruce budworm defoliation trend from 1947 thru 1990 on forest lands in the Blue Mountains (reproduced from Gast, et. al. 1991).

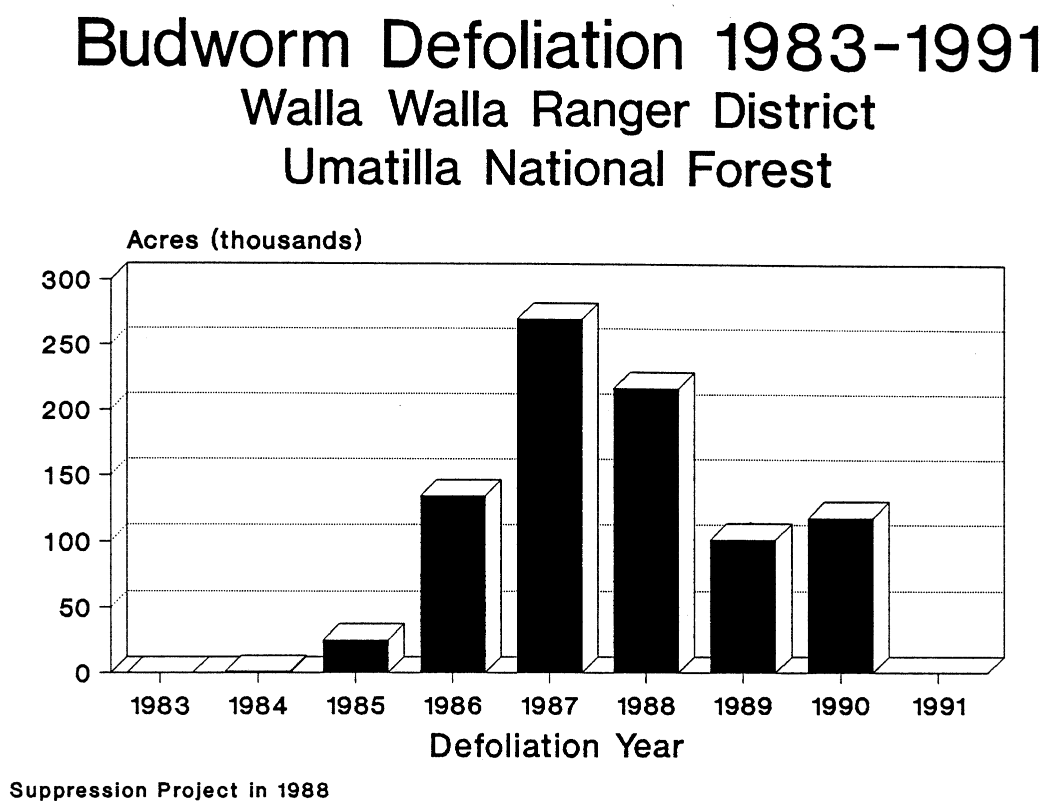



**Figure 2.** Western spruce budworm defoliation trend from 1983 thru 1991 on the Walla Walla Ranger District, Umatilla National Forest.

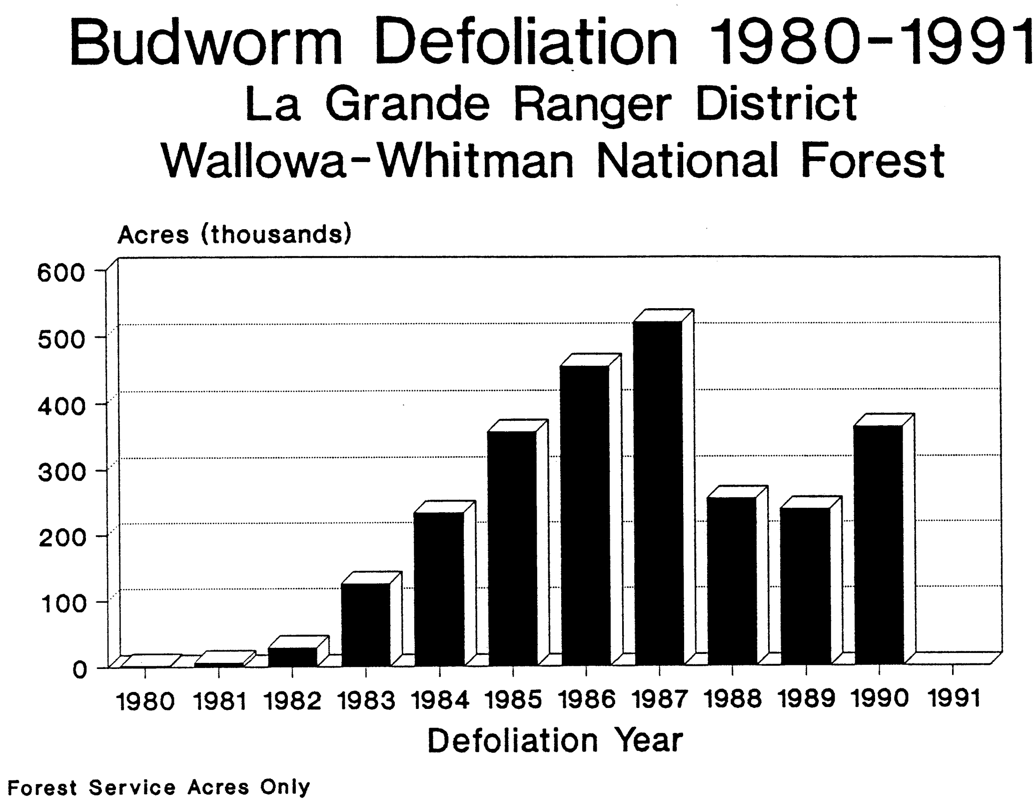



**Figure 3.** Western spruce budworm defoliation trend from 1980 thru 1991 on the La Grande Ranger District, Wallowa-Whitman National Forest.

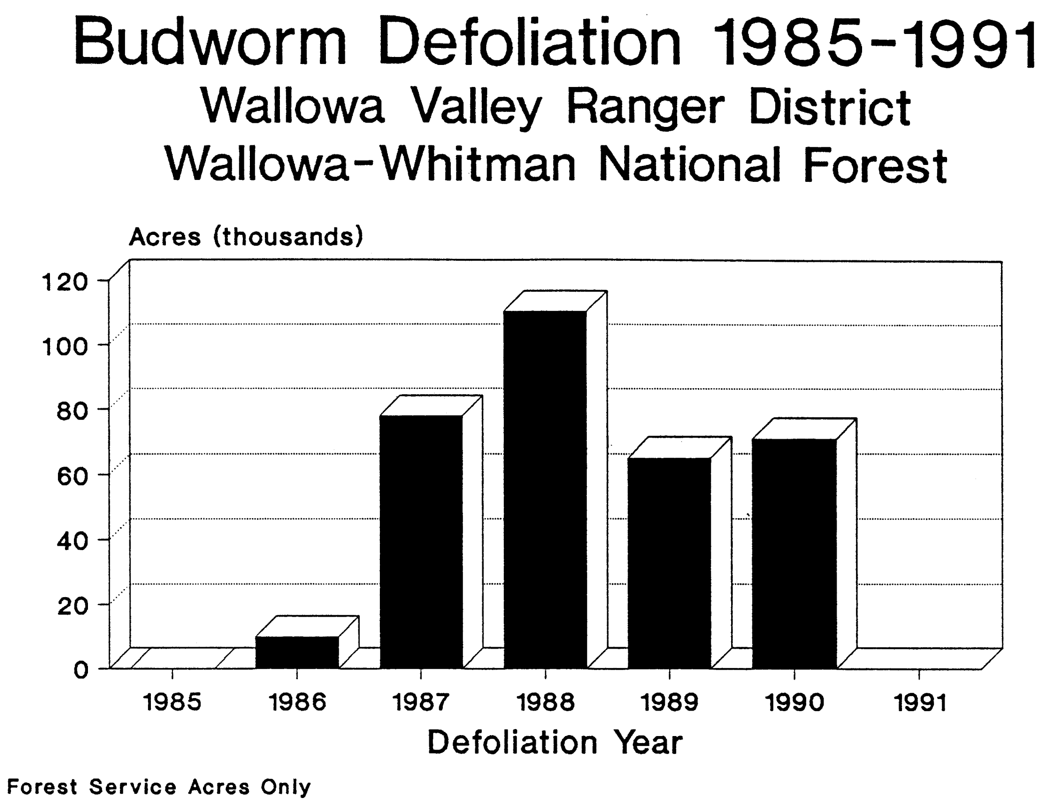
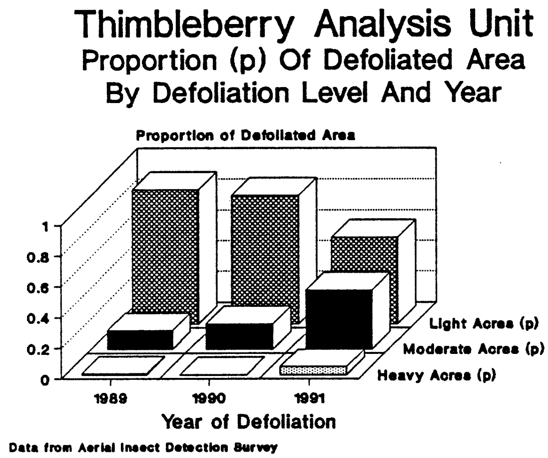



**Figure 4.** Western spruce budworm defoliation trend from 1985 thru 1991 on the Wallowa Valley Ranger District, Wallowa-Whitman National Forest.



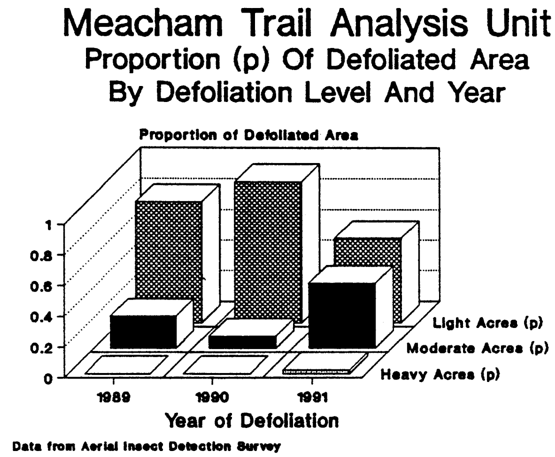
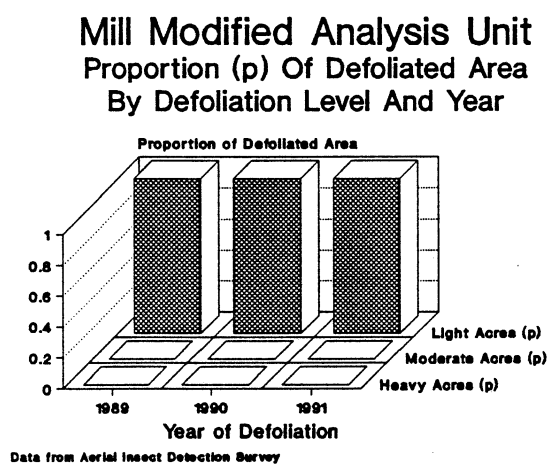
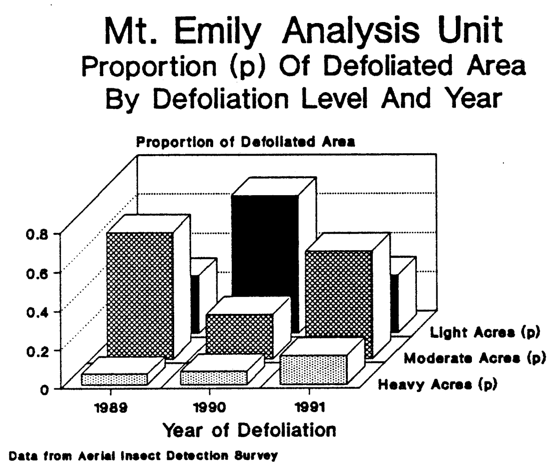




**Figure 5.** Proportion of acres of western spruce budworm defoliation by intensity on Walla Walla Ranger District 1992 Budworm Analysis Units, Umatilla National Forest.





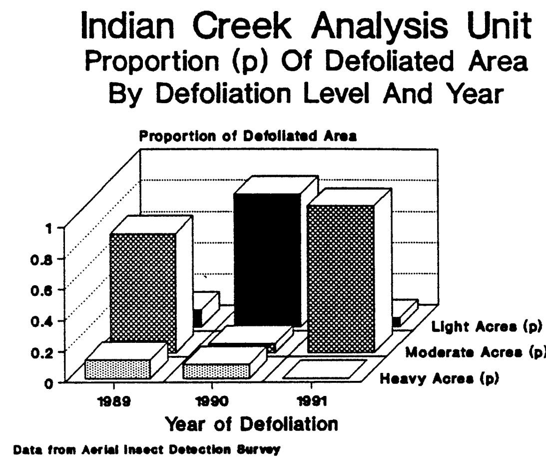
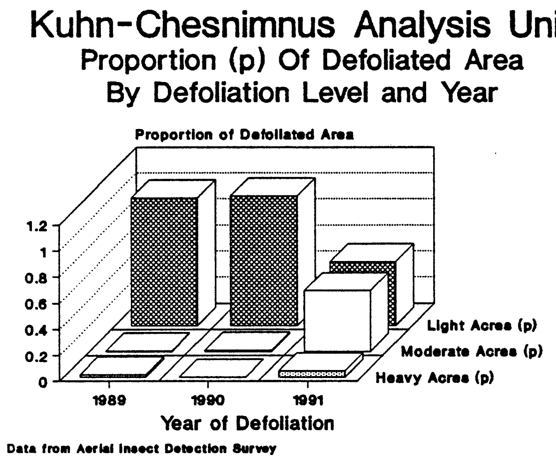




**Figure 6.** Proportion of acres of western spruce budworm defoliation by intensity on La Grande Ranger District 1992 Budworm Analysis Units, Wallowa-Whitman National Forest.



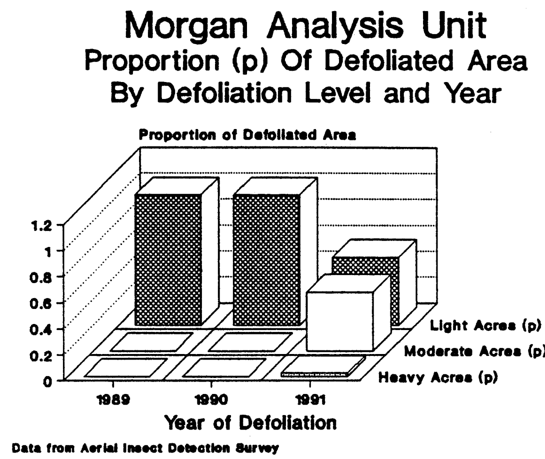




**Figure 7.** Proportion of acres of western spruce budworm defoliation by intensity on Wallowa Valley Ranger District 1992 Budworm Analysis Units, Wallowa-Whitman National Forest.